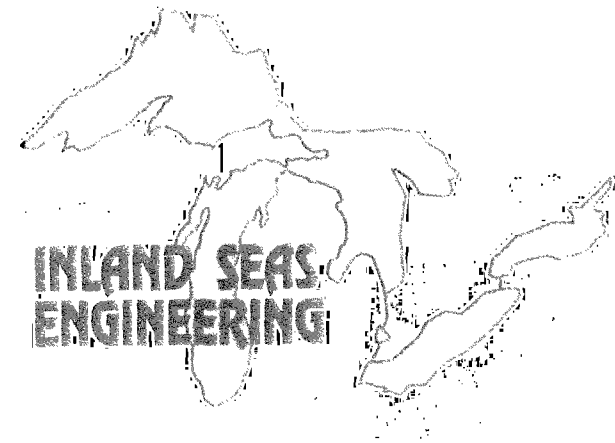
WRS
GT County
GW File



WORK PLAN
HYDROGEOLOGIC STUDY AND REPORT
CONSENT ORDER #NO. 31-07-02
SECTION IV(C.)(1.)
Williamsburg Receiving and Storage, L.L.C.
10190 Munro Road
October 14, 2002

INLAND SEAS ENGINEERING, INC.

(231) 933-4041
Traverse City, MI 49696

(810) 487-0555
Flushing, MI 48433

PROJECT Williamsburg Retaining & Storage

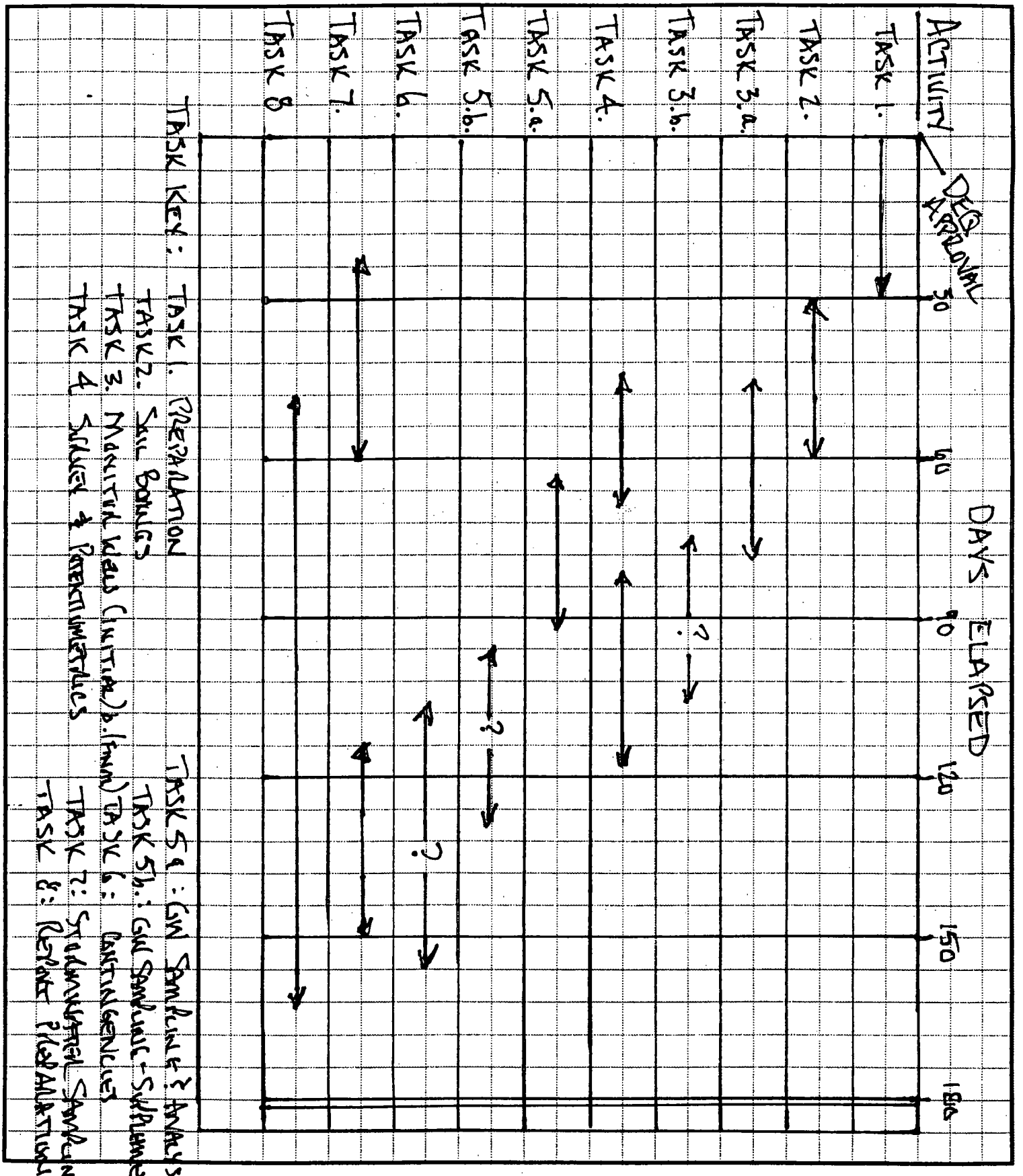
PROJECT NUMBER 02 399 04 - 10E

DATE 10-15-02

SHEET 1 OF 1

WEATHER APPENDIX I

CALCULATED BY AJS



WORK PLAN FOR HYDROGEOLOGIC STUDY AND REPORT

CONSENT ORDER #NO. 31-07-02 SECTION IV(C.)(1.)
Williamsburg Receiving and Storage, L.L.C.
10190 Munro Road
Whitewater Township, Michigan

INTRODUCTION

On August 16, 2002 Consent Order No. 31-07-02 (Order) became effective. This agreement between MDEQ and Williamsburg Receiving and Storage, L.L.C. (WRS) included several actions incumbent upon WRS enumerated within the Order's Compliance Program, Section IV. Section IV(c.)(1.) requires submittal of a Work Plan for a Hydrogeological Study (HS) and preparation of a HS Report (Report). The Work Plan must include a schedule for completion of the HS and submittal of the Report within 180 days following MDEQ's approval of the HS Work Plan.

The Order indicates that the HS is intended to, "***determine the impact of brine pits and wastewater discharges on groundwater***...". The Order requires the following be addressed by the HS:

1) Determine the nature and extent of contamination, if present, in the groundwater caused by the Facility's discharge and storage practices.
2) Describe the regional hydrogeologic conditions, including regional and local geology and surface and groundwater conditions, over an area sufficient to allow the department to determine the acceptability of discharging at the site under Part 31 of NREPA.
3) Define the areal and vertical extent and physical properties of the site earth materials that assimilate and transmit the discharge.
4) Determine whether the discharge is to a usable aquifer, an unusable aquifer, or groundwater not in an aquifer.
5) For an aquifer, determine the groundwater flow direction, groundwater velocity, 3-dimensional flow path of the discharge within the aquifer, interconnection between aquifers, and background and existing groundwater quality. For groundwater not in an aquifer, determine that the hydraulic or other physical properties, or both, are such that the formation would not be considered an aquifer.
6) Identify whether the discharge will occur within an established designated wellhead protection area or may occur within a proposed wellhead protection area.
7) Include a proposed groundwater monitoring plan meeting the requirements of R 23.2223(2) with sufficient information for the department to determine the acceptability of a proposed monitoring program.
8) Include a plan for characterization of water discharged to the collection basin east of the brine pits, and
9) Include a schedule of implementation.

Pursuant to Part 22 Rule 323.2221, the HS Report must contain the following information:

a) Information describing all pertinent current and historical land use practices at the site of discharge and at properties adjacent to the site of discharge.
b) A general description of the geology of the surrounding area and how it relates to the geology and hydrogeology of the discharge location, including formations used as water supplies in the area.

c) An area map that shows the direction of surface drainage, water supply wells, lakes, ponds, springs and wetlands.
d) A narrative description of the hydrogeologic data collected and interpretation of the data as it relates to satisfying the requirements of this rule.
e) Soil borings or other test methods to determine the composition of subsurface materials, locate usable aquifers, and determine the thickness of the usable aquifer.
f) Soil boring logs containing specified requisite information.
g) A scaled map of the site depicting soil borings, observation wells, test pits and other testing areas.
h) Cross-sections showing a 2-dimensional representation of the geology of the site sufficient to reflect the site geology and hydrogeology.
i) Testing of the unsaturated zone sufficient to determine the ability of site earth materials to transmit the discharge
j) Evaluation of vertical and horizontal extent of mounding resulting from the discharge.
k) Depth to groundwater and aquifer thickness of the usable aquifer receiving the discharge.
l) Interconnections between the aquifers receiving the discharge and other aquifers in the vicinity of the discharge location.
m) The horizontal and vertical gradients within the aquifer receiving the discharge.
n) Horizontal hydraulic conductivity, groundwater flow direction and calculated groundwater flow velocity.
o) Existing groundwater quality of the aquifer receiving the discharge.

This document is intended to satisfy Section IV(c.)(1.) of the Order and provide a Work Plan for the HS agreed to by the parties to the agreement.

WORK PLAN- GENERAL

Work Plan Requirements

Rule 2221(3)(b) provides the required elements to be included in a HS Work Plan. These are:

1 A map indicating the topography of the area with the discharge location identified.
2 A map indicating the surface geology of the area with the discharge location identified.
3 Logs of domestic wells adequate to characterize each water supply formation within ½ mile in all directions from the discharge.
4 A map shall be provided that correlates each well log to a specific map location.
5 A map delineating an established or proposed designated wellhead protection area that may be affected by the discharge.
6 The number, location, depth, drilling and development methods and well construction for all proposed observation wells to be drilled on-site
7 The number, location, depth, drilling and plugging methods for all proposed soil borings on-site, all of the following information:
8 A description of all physical testing to be done to identify soil properties and aquifer characteristics and locations where testing is to occur.
9 A groundwater sampling and analysis plan meeting the requirements of R 323.2223(2)(a).

Appendix A of this Work Plan (Plan) contains several figures that support the Plan and satisfy some of the submittal requirements stipulated in Rule 2221(3)(b). Figure 1 is a Site Location Map which depicts the WRS plant site location relative to physical and cultural features of the area. The figure is adapted from a United States Geological Survey (USGS) Quadrangle Map, thus topographic contours are included, satisfying requirement # 1. Requirement #2 is satisfied by provision of Figure 2A and 2B. These figures depict the site in the setting of the regional Quaternary Geology, and Soils Map of soil series developed in the region, respectively. Also in Appendix A is Figure 3, which depicts the location of area Water Well Records obtained from the Grand Traverse County Department of Environmental Health.

Appendix B contains the water well records plotted on Figure 3, with numeric codes printed in the upper right-hand corner. These numeric codes associate mapped locations with each record. While not a required Plan element, Figure 4 is a land use and watershed map that supports the Plan and will serve to satisfy a portion of the HS Report requirements. There is no map included with this Work Plan that depicts the extent of a Wellhead Protection Area, existing or proposed. There are no Type II or Type I water supply wells located anywhere in the vicinity of the WRS plant.

Hydrogeologic and Hydrologic Bases for Work Plan
Two (2) prior studies serve as technical bases for development of this Plan. These include:

- Water Resources Investigation Report 90-4122 by USGS, dated 1990
- Hydrogeologic Study of the Site (with Supplement) by Gray and Company, dated 1988

Summary of USGS Report Excerpts
Excerpts of the 1990 USGS Report and a copy of the 1988 HS Report are included in Appendix C and Appendix D, respectively. The first reference is entitled, "Hydrology and Land Use in Grand Traverse County, Michigan". The excerpted portions provide regional information compiled by USGS related to:

- Bedrock and Glacial Geology
- Surface and Groundwater Hydrology
- Land Use

The USGS Report documents the glacial geological domain in the vicinity of the WRS plant to be composed of till plains and end moraine deposits. The till plain in this area is recognized by the presence of drumlin landforms, one of which may be observed on Figure 1 just northeast of the WRS plant. The landforms are also shown on Figure 2A. Page 10 of the excerpted material in Appendix C depicts the relationships of these glacial depositional environments relative to one another in the vicinity of the WRS plant. Both till plains and end moraine complexes are relatively heterogeneous in nature due to their deposition being influenced both by moving glacial ice and by its melt water.

The USGS Report indicates that the depth to groundwater varies throughout the year and is influenced by seasonal variation in precipitation and evapotranspiration. This study affirms the annual average precipitation to be approximately 31 inches per year, with 16 inches lost to evapotranspiration and about four (4) inches of run off. This results in a net annual infiltration of 11 inches.

This just stating a fact from the 1990 Hydro report

How relevant is this now? let it go... Application is not for the same thing NOT the same owners Nothing was implemented

The USGS s [illegible] r Elk Rapids) ranged from [illegible] dy is the only significant su [illegible] surface water bodies in Wh [illegible] n surrounding the WRS plai [illegible]

Land uses do [illegible] the excerpted material in A [illegible] gricultural land use, while ap [illegible]. Figure 4 of Appendix A [illegible] is agricultural. Irrigation of t [illegible] 10 acres.

Summary of 1988 Hydrogeologic Study and 1989 Supplement

The 1988 HS Study Report was prepared for Gray and Company's proposed use of the WRS site as a brine cherry finishing wastewater discharge location. The HS Report was reviewed by MDNR in support of the wastewater discharge permit (M086) which was granted for the proposed use of the site. The report documents the installation of five (5) observation wells (MW-A through MW-E) and one (1) 4-inch, production well (4" well) at the site. The borings used to advance these wells provided some soil textural information throughout the northern portion of the WRS site. In addition, the HS Study included an aquifer pumping test, yielding a aquifer hydraulic characteristics and allowing for a calculation of mound development beneath the proposed discharge area.

The following hydrogeologic information is summarized from this report:

Transmissivity:	13,780 gpd/ft (1840 ft^2/day)
Storage Coefficient:	0.014
Depth to groundwater:	10 to 30 feet (northern portion of site, depends upon topography)
Hydraulic Gradient:	North (northern portion of site)
Soil Textures:	Intercalated fine sands and silts with clay and gravel strata
Proposed Application Rate:	0.23 gpd/ft^2
Proposed Application Volume:	44,444 gallons/day

The 1989 Supplement to the HS Report describes the installation of additional observation wells, designated MW-F through MW-H and a soil boring, designated SB-3. These were installed in the southern and eastern portions of the site. All boring and well locations reported in the prior HS are shown on Figure 5 of Appendix A. This figure illustrates these locations relative to the existing site plan. The principal findings from this supplemental work were the discovery of an apparent groundwater divide. This is evident on Figure 5 as the diverging hydraulic gradients depicted present over the northeastern and southeastern bringing pit areas. Groundwater elevations are generally equivalent with the gradients observed over multiple measurement events as both north and south.

The supplemental work confirmed the heterogeneity of the subsurface observed initially and also detected confining conditions in lower groundwater units giving rise to artesian head conditions. The presence of clay strata was observed in many borings. Boring SB-3, penetrated over 40 feet of moist clay before terminating without detection of a groundwater unit. This boring location is situated near

the apparent groundwater divide. The apparent hydraulic gradient to the north was reported to be approximately 1%, while the southern hydraulic gradient was presented at approximately 0.5 %.

Summary of Relevant Findings from Prior Studies

The USGS Report is general or regional in nature. Hydrogeologic data collected in the vicinity of the WRS plant is modest and situated several miles remote from the site. Character of the glacial deposits reported in the vicinity of the plant has been determined through the use of water well records and topographic maps.

Site-specific investigation of hydrogeologic conditions as documented in the 1988-1989 HS support the general findings from the USGS Report in terms of the complex glacial geology of this area. The presence of dense, clay till deposits of varying thickness and elevation and their presence above and below coarse, granular soils (both saturated and unsaturated) typify the glacial geologic setting depicted on Figure 2A. It is probable that multiple groundwater units exist beneath the site and that these are separated both vertically and horizontally by clay aquitards. Depth to the upper-most groundwater unit varies across the site and this variability is generally due to topographic relief. The presence of impervious clay till deposits also greatly affects the depth to the first water bearing unit. These clay strata are also likely to cause confining or partially confining conditions for lower groundwater units.

The lateral extent of any groundwater unit is also likely to be quite variable and affected by the presence or absence of clay deposits. This is evident from the somewhat spurious aquifer pumping test data and from the general absence of granular soils at the SB-3 location. The aquifer hydraulic testing yielded an estimate for transmissivity of the upper-most saturated zone, though this estimate must be qualified by the fact that not all the drawdown or recovery data was utilized in its genesis. Similarly, the soil textural information provided by the prior HS is limited by the paucity of discrete soil samples or other testing that allows for discernment of discrete strata boundaries and soil textural classes.

Hydrogeologic Study Target Areas

In order to, "***determine the impact of brine pits and wastewater discharges on groundwater...***", wastewater discharge areas and brining pit areas require hydrogeologic assessment. These areas can be categorized as follows:

- Active Brine Pit Areas (2 each)
- Former Brine Pit Areas (3 each)
- Former Spray Irrigation Area

Former Spray Irrigation Area

The former spray irrigation area is shown on the Figure 5 of Appendix A in the eastern reaches of the site. Figure 5 shows the presence of soil borings within each of the wastewater application areas served by the five (5) irrigation heads. These borings were advanced in July 2002 as part of an assessment of this area undertaken at the direction of WRS in compliance with their Permit conditions. Appendix E contains a full report of the July 2002 Spray Irrigation Area assessment. The findings from this assessment indicate that there has not been any impact upon groundwater resources beneath the Spray Irrigation Area attributable to the discharge of irrigation pond water to these areas in first quarter of 2002. No further inquiry of this area is recommended.

Former Brining Pit Area- Northwest

The brining pits in this area were recently decommissioned to provide for a storm water retention basin. Following removal of brining pit liners from the pits in this area, ISE was engaged to sample soil beneath the northwest pit area. This assessment was conducted using MDNR guidance for assessment of soil entitled, "***Verification of Soil Remediation, April 1994, Revision1***". The practices detailed in this guidance are intended to determine if unacceptable concentrations of hazardous substances exist in soil following in-situ remediation or removal actions. Though no removal action was undertaken, the practice provides a statistical rationale for assessment of soil conditions.

Appendix F contains a full report of this assessment. The findings from the assessment indicate that a facility condition does not exist in this area based upon soil sample analytical results. As this area was previously covered by impervious surfaces (liners), leaching of soluble brine constituents was precluded and soil assessment immediately following removal of liners provides a technically justifiable means of assessing the potential for impact. No further assessment of this area is recommended.

Former Brining Pit Area- South Central

The 1988 HS Report identifies the presence of ten (10) brine pits located immediately east of the current maintenance building, opposite the driveway. Currently, this area is occupied by a parking lot covered with bituminous pavement. The brine pits are shown on the HS Report Site Drainage Plan at an approximate surface elevation of 643 feet above mean sea level. Current elevations in this area are approximately 635 feet above mean sea level, suggesting that the site was graded following pit removal to fill the depression remaining after pits were removed. The removal date of pits from this area is currently unknown.

Former Brining Pit Area- Southwest

Cherry brining pits were reportedly once located between Angell Road and the plant building. It is believed that this area contained approximately ten (10) brine pits. These were thought to have been removed less than five (5) years ago. Currently, this area is occupied by a temporary stormwater retention basin for the plant roof drains. A small utility building is also present in this area which houses the pressure tanks formerly used for the plant water supply.

Active Brining Pit Areas- Northeast and Southeast

These brine pits are shown on Figure 5 of Appendix A. These total 20 pits in the northern battery and 35 pits in the southern battery. These pits are situated upon a plateau above the plant at an approximate elevation of 655 feet above mean sea level.

WORK PLAN- DETAILS

Potential Groundwater Impact Assessment Work Plan Details
The proposed work plan for assessment of potential impact of brine pit operation upon groundwater will focus upon the following areas that have not yet been subject to assessment activities:

- Former Brining Pit Area- South Central
- Former Brining Pit Area- Southwest
- Active Brining Pit Area- Northeast
- Active Brining Pit Area- Southeast

Field Work Preparatory Activities
Prior to mobilization for soil borings and monitoring well installations, review and evaluation of water well records and boring data from the prior HS will be undertaken. From these data, ISE will synthesize preliminary hydrogeologic cross-sections for the area. These will be used to refine the current understanding of the succession of quaternary geologic units. In doing so, specific soil sampling target depths and monitoring well screen intervals may be identified and used to refine the plan details provided below. Groundwater quality data will also be sought from State and local databases in an effort to establish the groundwater quality of the unit receiving the discharge and other groundwater units that may be connected to or isolated from that unit receiving the discharge.

The data synthesized from review of the existing hydrogeologic data will be evaluated in the context of the detailed plans proposed below. From this effort, technical specifications for drilling contractors and analytical laboratory service providers will be prepared. The technical specifications will be used to solicit proposals for professional service providers and trade contractors. In addition, requisite field testing equipment will be calibrated and field data recording forms will be finalized for use.

Soil Boring and Monitoring Well Installation Plan
Figure 6 of Appendix A is a Site Plan showing the former location of the 1988 HS observation wells and soil borings relative to current site occupations. Also depicted are the potentiometric surfaces determined by prior assessors. This figure also shows four (4) assessment areas identified immediately above. In these areas soil borings will be advanced and observation wells installed. The proposed locations are shown on Figure 6 and are distinguished from one another by their area descriptor. These are indicated as follows:

Series 100 Area-	South Central Former Brining Pit Area
Series 200 Area-	Southwest Former Brining Pit Area
Series 300 Area-	Northeast Active Brining Pit Area-
Series 400 Area-	Southeast Active Brining Pit Area-

The hydrogeology of this region will likely be governed by the dominant groundwater sinks (Tobeco Creek and Elk Lake) and sources (upland recharge) in the area. The presence and continuity of relatively impermeable soil types will also exert great influence upon the characteristics of groundwater units. Based upon these governing circumstances and ground elevations within each Series area, preliminary target soil sampling depths are shown in the table below. The Depth to

Tobeco" column is the estimated depth from ground surface to the elevation of Tobeco Creek. The following table summarizes the elevations and depths of key study objectives:

Series Area	Ground Elevation	Depth to Water	Depth to Aquitard	Depth to Tobeco
100	635	10'	20' ?	30'
200	630	5'	?	25'
300	655	30'	?	50'
400	655	30'	?	50'

Figure 6 of Appendix A shows the proposed locations of these borings. Based upon the relevant findings from prior studies, the proposed locations will provide essential hydrogeologic information in the area of interest. Borings locations are proposed in a manner that allows evaluation of the up-gradient and down-gradient reaches of each area's upper-most saturated zone. The measurement and evaluation of potentiometric levels at all locations should provide adequate information to ascertain groundwater flow direction. This information will be used in an evaluation of monitoring well locations to insure that proposed monitoring wells are capable of assessing the potential impact of brining pits on groundwater quality. Contingent monitoring well locations may be identified from this evaluation.

Stratigraphic Test Borings

Within each assessment area, borings will be advanced for the purpose of observing and evaluating the textural character and thickness of soil units from the surface to the base of the upper-most groundwater unit. These stratigraphic test borings are necessary to provide the information required by Rule R 323.2221. Test borings will be advanced in each of the four (4) areas to a maximum bottom elevation of approximately 580 feet mean sea level (MSL).

At each boring location, soil sampling will be conducted continuously from ground surface to a depth of 20 feet or upon encountering the saturated zone, whichever is attained first. Below this depth, soil samples will be acquired at least every five (5) feet using a 18 to 24-inch barrel sampler with brass or acetate liners. This protocol will be employed until a depth of 40 feet is reached or until the elevation of Tobeco Creek (≈ 605 MSL) is attained, whichever objective is attained earlier.

If the zone of saturation is not encountered at or before the borehole reaches and elevation of 600 feet MSL, the test boring advancement will continue with discrete soil samples acquired every ten (10) feet of borehole depth until a bottom-hole elevation of 580 feet MSL is attained. If the zone of saturation is not observed at or above this elevation (equivalent to Lake Michigan elevation) it will be concluded that an aquifer is not present at this location and the borehole will be plugged and abandoned.

If a zone of saturation 36-inches or greater in thickness is encountered above 580 feet MSL, then the borehole advancement will continue along with discrete soil sampling until the lower bounding soil horizon is encountered or until the bottom hole elevation of 580 feet is achieved. Upon encountering soil with texture supporting its presence as an aquitard or aquiclude, discrete soil sampling intervals will shift from the prescribed frequency to continuous. Upon acquisition of two (2) consecutive

is this standard (reasonable?). DEQ P.M should be involved in the process.

discrete soil samples demonstrating the minimum thickness of the lower bounding soil texture, the borehole will terminate and a monitoring well will be installed.

The decision to terminate a boring, modify discrete soil sampling intervals, construct a monitoring well, plug a borehole or seal any breaches in impermeable formations will be at the sole discretion of ISE's Project Geologist and the Project Manager. Decisions related to borehole advancement, completion or abandonment will be based upon the objectives of the Hydrogeologic Study, site-specific subsurface observations and the judgment of State-licensed professionals. If decisions by the Project Geologist or Project Manager render the boring incomplete or otherwise adversely affect the ability of the boring to attain the information requisite in accordance with the HS objectives, then contingent investigative measures will be undertaken as described below.

Monitoring Well Installation Development and Completion

Monitoring wells will be installed in the upper-most saturated zone within each assessment area. The monitoring wells are intended to provide potentiometric surface elevations and groundwater samples representative of the water within each saturated zone. Monitoring wells will be constructed using polyvinyl chloride (PVC) materials. The diameter of these well materials is not currently specified. Selection of well diameter will be based upon site-specific hydrogeologic conditions, professional judgment and economics of alternatives.

Development of monitoring wells will be undertaken prior to sampling. Methods used for development will be based upon site-specific hydrogeologic conditions and monitoring well construction. Development methods will conform with those identified below. Development waters will be discharged to the ground near each well location in a manner that conforms with generic discharge permit exemption criteria. Containerization and characterization of development waters will not be undertaken.

Typical monitoring well construction practices are detailed in Appendix H, where a typical monitoring well construction record is provided. In areas subject to vehicular or pedestrian traffic, well enclosures and/or protective barriers will be used to protect public health and the integrity of the monitoring well. When not in use, wells will be sealed with vented caps and enclosures will be secured to mitigate the potential for vandalism or sample bias.

<u>Acquisition of Potentiometric Surface Elevations</u>

Following installation of monitoring wells and their development, a topographic survey will be conducted to ascertain their "as-built" locations and elevations of the ground and top of casing. Measurements from the top of casing to the static water levels will be acquired twice per month over the course of several months. From these measurements and the elevations established from the survey, the elevation of the water table within the upper-most saturated zone will be calculated. These elevations of the potentiometric surface will be established by interpolation, where professional judgment and site-specific hydrogeological conditions warrant. From these interpolations, elevations of equal magnitude will be contoured. The horizontal hydraulic gradient and its direction(s) will be estimated from these data. Contingent assessment activities if necessary, will be based in part upon these results.

V what is standard! Surge block method

This ok?
Yes

Proposed Methods for Execution of HS Activities

Practices to be used to advance borings, sample and classify soil, construct monitoring wells, gauge water depths, etc. will follow American Society for Testing and Materials (ASTM) Standard Practices. The Standard Practices relevant to the HS work proposed are provided in Appendix G. This Appendix contains a copy of the Table of Contents from an ASTM compendium of Standards related to site characterization. The Practices relevant to the HS are indicated clearly within the Appendix.

Contingencies

If results from assessment activities indicate that the objectives of the HS cannot be met by proposed assessment activities, or if the data reveal that proposed monitoring locations are not suited to provide an assessment of the potential impact of brining operations upon groundwater resources, then contingent assessment activities will be undertaken to complete the objectives of the HS. Contingencies that may reasonably arise include:

must be a SWAO or WMO what rule. does this mean? They don't have to sample & monitor? I don't think

1. No saturated zone within the target area
2. An aquitard is absent at a reasonable depth below the saturated
3. Indeterminate hydraulic gradient or multiple gradient directions
4. Monitoring well positioned outside the flow path of groundwater from the assessment area
5. The upper-most saturated zone or its basal aquitard is too thin to effectively monitor
6. The upper-most saturated zone requires wells developed at multiple levels to adequately monitor

Should these contingency conditions arise, MDEQ will be notified in writing of the presence and character of the contingency condition and ISE's proposed response to overcome the condition impeding the objective of the HS. Responses may reasonably include alternate drilling techniques, addition or relocation of monitoring wells, employment of surface geophysical techniques, etc.

Groundwater Sampling and Analysis Plan

Rationale

The Order requires that a groundwater sampling and analysis plan be developed to satisfy the objectives of the HS. Existing Permit limitations and revised discharge operating practices have the effect of rendering future wastewater discharges from stemming and pitting operations harmless to groundwater resources. This results from discharge limitations at or below Rule R323.2222 default standards. Operating practices will include characterization of impounded stemming and pitting wastewater prior to its discharge to ensure compliance with Permit Limitations. Therefore, no monitoring program is proposed for permitted spray irrigation areas.

Of the four (4) targeted assessment areas, two (2) remain in use for processing cherries. As the majority of these areas are covered with impervious materials, groundwater monitoring downgradient of these areas is an appropriate mechanism for evaluating the potential impact of these operations upon groundwater resources. The two (2) former cherry brine pit areas have not used or have been subject to the leaching action of precipitation for some time. Therefore, no assessment of soil has been proposed to evaluate the concentrations of brine constituents within soil. Groundwater monitoring of these areas is a viable and practical means to evaluate the potential impact from operations in these area upon groundwater resources.

NO WAY Historically OK. Brine leaches thru Soil Column Quickly

Only chloride ions? Reasonable? Methods to be

Groundwater Sampling and Analysis Plan

Groundwater sampling will be conducted from all monitoring wells shown to be positioned downgradient from an assessment area. This evaluation will be completed following collection and assessment of at least two (2) separate potentiometric surface measurement events. If more measurements and evaluations are needed to confirm the horizontal hydraulic gradient, or if other contingent measures are necessary to ensure that monitoring wells are technically capable of serving their assessment function, then these measure will be undertaken prior to groundwater sampling.

Monitoring well sampling will be conducted in accordance with Standards included in Appendix G. Purging water will be contained until is evident from laboratory analyses that these waters may be discharged to the ground in accordance with generic permit discharge criteria. Samples acquired from these wells will be analyzed in accordance with methods stipulated in Part 22 Rules for chloride ion concentration. The use of chloride ions as an indicator is technically justified as this element is the most prevalent constituent in cherry brine. It is further justified for use as an indicator of potential impact since it is non-reactive and completely soluble in groundwater.

It is proposed that at least five (5) wells serve as sampling locations for the Sampling and Analysis Plan. These include one (1) well for each assessment area and one (1) background monitoring well. One (1) prospective location for the background monitoring well is shown on Figure 6 of Appendix A. These wells will be sampled on two (2) separate events to serve as initial and confirmatory measurements. Reasonable outcomes could include:

1. Both events indicate no chloride concentrations above Part 201 drinking water criteria
2. Both events indicate chloride concentrations above Part 201 drinking water criteria
3. Each event indicate differing chloride concentrations, both above and below Part 201 criteria

No more than

In the event that outcome 1. is observed, then no further sampling is proposed. In the event that outcome 2. is observed, then contingent well installations will be undertaken and additional brine constituents characterized in an effort to identify the specific source of the chloride and to delineate the spatial extent of impact to groundwater resources resulting from WRS operations. Appropriate initial response measures will also be undertaken, including inventory analyses, to abate the potential for a release. If outcome 3. is experienced, then sampling and analyses will continue until either one observation or the other is confirmed or until six (6) sampling results are available to determine the estimated mean chloride concentration at a 95% confidence level.

Stormwater Characterization for Discharges to the Basin East of the Eastern Brine Pits

Stormwater characterization for this element of the Order will be conducted in accordance with the exacting requirements stipulated in the order. Sampling will be undertaken with two (2) events planned for 2002 and the remaining two (2) events will occur in 2003. Sampling locations will be at the outfall of each pipe. These locations will be designated North Outfall-East Basin and South Outfall-East Basin. Analyses will be conducted in accordance with the Order and methods stipulated in Part 22 Rules.

1.- Monitor for more than 3 Sampling events
2.- No clean up.
3.

Hydrogeological Study Report

Following completion of all proposed activities, a HS Report will be prepared to address the expressed intent of the Order, that is to determine the impact of brine pits and wastewater discharges upon groundwater. The HS Report will conform with requirements provided by Rule R 323.2221. Information from prior studies, such as Transmissivity and Mounding estimates, that serve to satisfy the requirements of R 323.2221 will be incorporated in the HS Report. The Report will be submitted in accordance with the Order and the implementation schedule discussed below.

Schedule for Hydrogeological Study and Report Preparation

Appendix I contains a Gantt Chart providing the proposed schedule of activities relative to the DEQ's approval of the HS Work Plan.

Prepared by:
INLAND SEAS ENGINEERING, INC.

Andrew Smits, P.E.
Geological Engineer

APPENDIX A

FIGURES AND TABLES

FIGURES

Pages 18-25 Exemption 9

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION

WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978
Failure to comply is a misdemeanor

TAX NO: 28-1-109-019-00

PERMIT NO: 27497 well #2

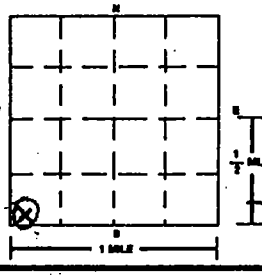
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
GRAND TRAVERSE	WHITEWATER	SW1/4 SW1/4 SW1/4	9	28N	9W

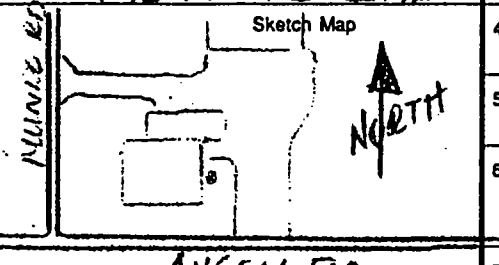
Distance and Direction from Road Intersection
~200' NORTH OF ANCELL ROAD
~400' EAST OF MUNRO ROAD
PLANT WELL

Street Address & City of Well Location: 10190 MUNRO ROAD

Locate with 'x' in Section Below



Sketch Map



3. OWNER OF WELL: WILLIAMSBURG RECEIVING & STORAGE INC.
Address: 10190 MUNRO RD. WILLIAMSBURG, MI
Address Same as Well Location: [X] Yes [ ] No

4. WELL DEPTH: 148 ft. Date Completed: 5-15-00 [X] New Well [ ] Replacement Well

5. [ ] Cable Tool [X] Rotary [ ] Driven [ ] Dug [ ] Hollow Rod [ ] Auger/Bored [ ] Jetted [ ]

6. USE: [ ] Household [ ] Type I Public [X] Type III Public [ ] Irrigation [ ] Type IIa Public [ ] Heat Pump [ ] Test Well [ ] Type IIb Public [ ]

7. CASING: [ ] Steel [ ] Threaded [X] Plastic [ ] Welded [ ] Other
Diameter: ___ in. to ___ ft. depth; 5" in. to 128 ft. depth
BORE HOLE: Diameter: ___ in. to ___ ft. depth; 8¼" in. to 148 ft. depth
Height: Above/Below Surface: 1 ft
Weight: SDR21 lbs./ft.
[ ] Drive Shoe [ ] Shale Packer

2. FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand streaks of Gravel	46	46
Sand, clay	9	55
clay	28	83
Sand	3	86
clay	26	112
Sand	36	148

USE A 2ND SHEET IF NEEDED

8. SCREEN: [ ] Not Installed [ ] Gravel-Packed
Type: Stainless Steel Diameter: 4"
Slot/Gauge: 10 Length: 20'
Set Between: 128 ft. and 148 ft.
FITTINGS: [X] K-Packer [ ] Bremer Check
[X] Blank Above Screen: 1 ft. Other

9. STATIC WATER LEVEL: 15 ft. Below Land Surface [ ] Flowing

10. PUMPING LEVEL: Below Land Surface
___ ft. After 1 hrs. Pumping at 80+ G.P.M.
[ ] Plunger [ ] Bailer [X] Air [ ] Test Pump

11. WELL HEAD COMPLETION:
[X] Pitless Adapter [X] 12" Above Grade
[ ] Basement Offset [ ] Well House

12. WELL GROUTED? [ ] No [X] Yes From 0 to 118 ft.
[ ] Neat Cement [ ] Bentonite [X] Other Volclay
No. of Bags: 5 Additives:

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type: Septic Distance: 180 ft. Direction:
Type: Distance: ft. Direction:

14. PUMP: [ ] Not Installed [ ] Pump Installation Only
Manufacturer's Name: Red Jacket
Model Number: 500F5CNS10EC HP: 5 Volts: 460/380
Length of Drop Pipe: 84' ft. Capacity: 80 G.P.M.
TYPE: [X] Submersible [ ] Jet [ ] Other
PRESSURE TANK: 2" Galv. Drop
Manufacturer's Name: #5-Well Extrols
Model Number: WX350 Capacity: 119 Gallons

15. ABANDONED WELL PLUGGED? [X] Yes [ ] No
Casing Diameter: 8" in. Depth: 7 ft.
PLUGGING MATERIAL: [X] Neat Cement [ ] Bentonite Slurry [ ] Cement/Bentonite Slurry [ ] Concrete Grout [X] Bentonite Chips
No. of Bags: 6 Casing Removed? [ ] Yes [X] No

16. REMARKS: (Elevation, Source of Data, etc.) Abandoning completed w/ cement by Elmers. PLANT Well

17. DRILLING MACHINE OPERATOR:
[X] Employee [ ] Subcontractor
Name: Douglas Schettek

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
PHIL'S WELL DRILLING, INC. REGISTERED BUSINESS NAME — C481 REGISTRATION NO.
Address: 3783 Keyser School Rd. Traverse City MI
Signed: [signature] AUTHORIZED REPRESENTATIVE Date: 6-6-00

RECEIVED JUN 09 2000

LOCAL HEALTH DEPT. COPY

EQP 2017 (12/96)

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION

WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978
Failure to comply is a misdemeanor

TAX NO:

PERMIT NO: 9-2

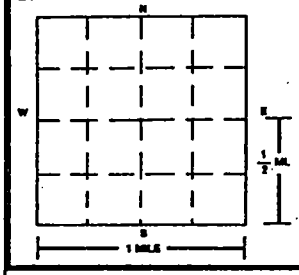
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
GRAND TRAVERSE	WHITEWATER	SW1/4 SW1/4 SW1/4	9	28N	9W

Distance and Direction from Road Intersection
NE corner of Angel and Monroe Road

Street Address & City of Well Location

Locate with 'x' in Section Below — Sketch Map



3. OWNER OF WELL: Williamsburg Receiving & Storage
Address: 10190 Monro Road, Williamsburg, MI 49690

Address Same as Well Location ☒ Yes ☐ No

4. WELL DEPTH: 120 ft. | Date Completed: 06/19/00 | ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐ _____

6. USE: ☐ Household ☐ Type I Public ☒ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐ _____

7. CASING: ☒ Steel ☐ Threaded ☐ Plastic ☐ Welded ☐ Other _____
Diameter: 12 in. to 100 ft. depth
_____ in. to _____ ft. depth
BORE HOLE:
Diameter: 17.5 in. to 124 ft. depth
_____ in. to _____ ft. depth
Height: Above/Below Surface: 2.8 ft
Weight: 49.56 lbs./ft.
☐ Drive Shoe ☐ Shale Packer

8. SCREEN: ☐ Not Installed ☒ Gravel-Packed
Type Stainless Diameter 12"
Slot/Gauze .030 Length: 20'
Set Between 100 ft. and 120 ft.
FITTINGS: ☐ K-Packer ☐ Bremer Check
☐ Blank Above Screen _____ ft. Other Weld on

9. STATIC WATER LEVEL:
14.80 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface
115 ft. After 1 hrs. Pumping at 300-500 G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION:
☐ Pitless Adapter ☒ 12" Above Grade
☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 7 to 100 ft.
☒ Neat Cement ☐ Bentonite ☐ Other _____
No. of Bags 42 Additives _____

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type Septic Distance 100 ft. Direction NW
Type Fuel Storage Distance 112 ft. Direction W

14. PUMP: ☒ Not Installed ☐ Pump Installation Only
Manufacturer's Name _____
Model Number _____ HP _____ Volts _____
Length of Drop Pipe _____ ft. Capacity _____ G.P.M.
TYPE: ☐ Submersible ☐ Jet ☐ Other _____
PRESSURE TANK:
Manufacturer's Name _____
Model Number _____ Capacity _____ Gallons _____

2. FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Brown medium sand with coarse gravel	3	3
Brown sandy clay with coarse gravel	8	11
Brown medium sand	9	20
Brown medium to coarse sand	4	24
Brown medium sand with fine gravel	5	29
Brown medium sand	12	41
Brown medium sand with fine gravel	51	92
Dark brown sandy clay	3	95
Brown medium sand	4	99
Brown medium sand with fine gravel	28	127
Hard dark brown sandy clay, dry	3	130
Brown medium sand with fine gravel	—	137

USE A 2ND SHEET IF NEEDED

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter _____ in. Depth _____ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry ☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags _____ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)
Total depth of test boring - 137'

17. DRILLING MACHINE OPERATOR:
☒ Employee ☐ Subcontractor
Name HERRON, RICHARD

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
STEARNS DRILLING COMPANY — REGISTERED BUSINESS NAME — 41-1095 — REGISTRATION NO.
Address 6974 HAMMOND AVENUE, SE, DUTTON, MI 49316-9116
Signed Richard L. Herron — AUTHORIZED REPRESENTATIVE — Date 6-9-00

RECEIVED JUN 13 2000

LOCAL HEALTH DEPT. COPY

EQP 2017 (12/96)

GEOLOGICAL SURVEY SAMPLE No. [ ]

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

9-3

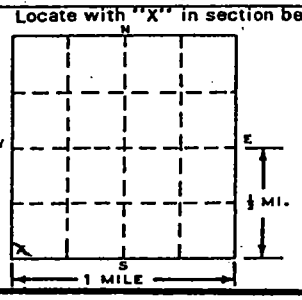
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Grand Traverse	Whitewater	SW¼ SW¼ SW¼	9	28 N/S.	9 E/W.

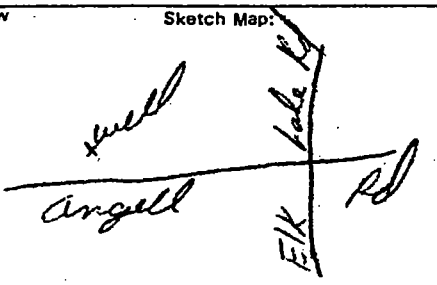
Distance And Direction from Road Intersections: ½ mile West of Old Lake Rd on Angell Rd,

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL: Robert Morrison

Address: RR#2 Williamsburg Mich 49690

4 WELL DEPTH: (completed) 148 ft. Date of Completion 7/3/78

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ] ____

6 USE: [ ] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [X] Commercial [ ] Test Well [ ] ____

7 CASING: Threaded [X] Welded [ ] Diam. 4 in. to 146 ft. Depth; ____ in. to ____ ft. Depth. Height: Above/~~Below~~ Surface 18 ft. Weight 11 lbs./ft. Drive Shoe? Yes [X] No [ ]

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Coarse Sand	55	55
Red Clay & Sand	45	100
Red Clay	40	140
Water Sand	8	148

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: Stainless Dia.: 4" Slot/Gauze 10 Length 8' Set between 140 ft. and 148 ft.

Fittings: Plug - 4" Clark - Kinder

9 STATIC WATER LEVEL 25 ft. below land surface

10 PUMPING LEVEL below land surface 30 ft. after 1 hrs. pumping 70 g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: [ ] In Approved Pit [X] Pitless Adapter [ ] 12" Above Grade

13 Well Grouted? [ ] Yes [X] No [ ] Neat Cement [ ] Bentonite [ ] ____ Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination 100 feet W Direction Cesspools Type

Well disinfected upon completion [ ] Yes [ ] No

15 PUMP: [ ] Not Installed

Manufacturer's Name Flint + Walling

Model Number ____ HP 3 Volts 230

Length of Drop Pipe 63 ft. capacity 70 G.P.M.

Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Towars Well Drilling 1241
REGISTERED BUSINESS NAME REGISTRATION NO.

Address 1747 Linden Ave T.C.

Signed Duane Towars Date 9/13/78
AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY NO. [ ]

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

PERMIT NUMBER 9-4

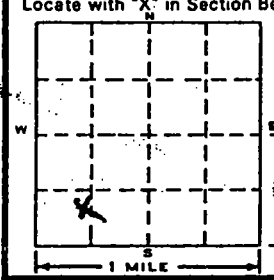
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	NE ¼ SW ¼ SW ¼	9	28 N	9 W

Distance And Direction From Road Intersection: .2 MI. NO. OF ANGEL RD ON E. SIDE OF MUNRO

Street Address & City of Well Location

Locate with "X" in Section Below



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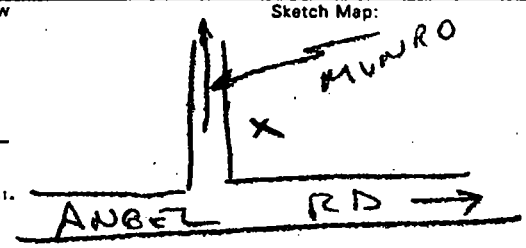


3 OWNER OF WELL: GRAY & CO % CHRIS NUBB
Address 8285 Bunk Rd WILLIAMSBURG, MI
Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH: (completed) 23½ ft. | **Date of Completion** 8-29-88

5 ☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Auger ☐ Jetted ☐ _____

6 USE: ☐ Domestic ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat pump ☐ Test Well ☐ Type IIb Public ☒ MONITOR

7 CASING: Diameter ☒ Steel ☐ Threaded ☐ Plastic ☒ Welded
Height: Above/Below Surface ' ft.
Weight 9 lbs./ft.
1¼ in. to 4 ft. depth
_____ in. to _____ ft. depth
Grouted Drill Hole Diameter
4 in. to 23½ ft. depth
_____ in. to _____ depth
Drive Shoe ☐ Yes ☒ No

8 SCREEN: ☐ Not Installed
Type STAINLESS 10 Diameter 4 IN (in)
Slot/Gauge _____ Length 3 FEET
Set between 20½ ft. and 23½ ft.
FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check
☒ Blank above screen 1 ft. Other _____

9 STATIC WATER LEVEL: 10 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface
_____ ft. after _____ hrs. pumping at _____ G.P.M.
_____ ft. after _____ hrs. pumping at _____ G.P.M.

11 WELL HEAD COMPLETION: ☐ Pitless adapter ☒ 12" above grade ☐ Basement offset ☐ Approved pit

12 WELL GROUTED? ☐ No ☒ Yes From _____ to _____ ft.
☐ Neat cement ☒ Bentonite ☒ Other VOLCLAY
No. of bags of cement _____ Additives _____

13 Nearest source of possible contamination
Type _____ Distance FIELD ft. Direction _____
Well disinfected upon completion? ☐ Yes ☐ No

14 PUMP: ☒ Not Installed ☐ Pump Installation Only
Manufacturer's name _____
Model number _____ HP _____ Volts _____
Length of Drop Pipe _____ ft. capacity _____ G.P.M.
TYPE: ☐ Submersible ☐ Jet _____
PRESSURE TANK:
Manufacturer's name _____
Model number _____ Capacity _____ Gallons

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SANDY CLAY	15	15
CLAY	3	18
WATER SAND	5½	23½

USE A 2ND SHEET IF NEEDED

15. Remarks, elevation, source of data, etc.
RECEIVED NOV 15 1988
DRILLER: ROBERT NELSON

16. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
PHIL'S WELL DRILLING 0481
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 10785 GRANDVIEW RD TC
Signed _____ Date 11/8/88
AUTHORIZED REPRESENTATIVE

D67d 2/84

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY NO.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

PERMIT NUMBER 9-5

28-13-109-101-90

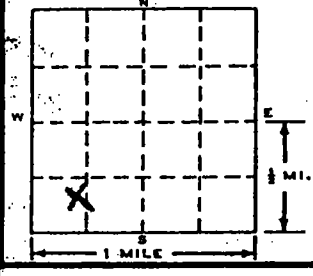
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	NE¼ SW¼ SW¼	9	28 N	9 W

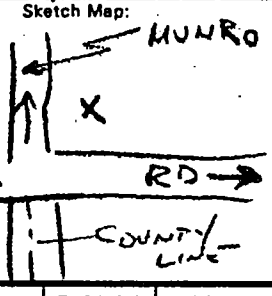
Distance And Direction From Road Intersection: .2 MI S of ANGEL OFF MUNRO (EAST) (CHERRY PACKING PLANT)

Street Address & City of Well Location: 10156 MONROE Rd.

Locate with "X" in Section Below



Sketch Map:



3 OWNER OF WELL:

Address: GRAY & Co CHRIS HUBBEL 8385 Park Rd WILLIAMS

Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH: (completed) 39 ft. **Date of Completion** 8-26-88

5 ☐ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☒ Auger ☐ Jetted ☐

6 USE: ☐ Domestic ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat pump ☐ Test Well ☐ Type IIb Public ☒ MONITOR

7 CASING: Diameter ☒ Steel ☐ Threaded ☐ Plastic ☐ Welded

____ in. to ____ ft. depth

____ in. to ____ ft. depth

Grouted Drill Hole Diameter

____ in. to ____ ft. depth

____ in. to ____ ft. depth

Height: Above/Below Surface 1 ft.

Weight ____ lbs./ft.

Drive Shoe ☐ Yes ☐ No

2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
HEAVY SANDY CLAY	15	15
CLAY	2	17
WATER SAND	22	39
CLAY ON BOTTOM	2	

WELL ABANDONED AND TESTED

USE A 2ND SHEET IF NEEDED

8 SCREEN: ☐ Not Installed

Type STAINLESS Diameter 4 INCH

Slot/~~Gauge~~ 10 Length 12 FEET

Set between 27 ft. and 39 ft.

FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check

☒ Blank above screen 1 ft. Other ____

9 STATIC WATER LEVEL: 15 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface

____ ft. after ____ hrs. pumping at ____ G.P.M.

____ ft. after ____ hrs. pumping at ____ G.P.M.

11 WELL HEAD COMPLETION: ☐ Pitless adapter ☐ 12" above grade ☐ Basement offset ☐ Approved pit

12 WELL GROUTED? ☐ No ☐ Yes From ____ to ____ ft.

☐ Neat cement ☐ Bentonite ☐ Other ____

No. of bags of cement ____ Additives ____

13 Nearest source of possible contamination

Type ____ Distance ____ ft. Direction ____

Well disinfected upon completion? ☐ Yes ☐ No

14 PUMP: ☐ Not Installed ☐ Pump Installation Only

Manufacturer's name ____

Model number ____ HP ____ Volts ____

Length of Drop Pipe ____ ft. capacity ____ G.P.M.

TYPE: ☐ Submersible ☐ Jet ____

PRESSURE TANK:

Manufacturer's name ____

Model number ____ Capacity ____ Gallons

15. Remarks, elevation, source of data, etc.

RECEIVED NOV 15 1988

DRILLER: BOB NELSON

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

PHIL'S WELL DRILLING 0481

REGISTERED BUSINESS NAME REGISTRATION NO.

Address 10785 GRANDVIEW RD TC

Signed [signature] 11-8-88

AUTHORIZED REPRESENTATIVE

Authority: Act 368 PA 1978

Completion: Required

Penalty: Conviction of a violation of any provision is a misdemeanor.

D67d 2/84

LOCAL HEALTH DEPT. COPY

Grocers & H.D.

14

9-6

Layne NORTHERN COMPANY INCORPORATED

INDIANAPOLIS • MISHAWAKA • LANSING

(631)

WELL #3

☐ TEST

☒ PERMANENT

Job No. 16394

WELL LOG No. 2 CITY Traverse City County Grand Traverse

Owner Silver Mills Frozen Foods Township White Water

Section 9

Location State Michigan

From Land Description 50' E. of SE corner of main bldg.

From Street or Road Approx 300' N. of Angle Rd.

FORMATION FOUND -- DESCRIBE FULLY	FROM NATURAL GROUND LEVEL			
	Depth to Top of Stratum	Depth to Bottom of Stratum	Thickness of Stratum	Static Water Level
Med to coarse sand - brown	0	42	42	
Clay Red	42	43	1	
Med. to coarse sand light grey	43	83	40	17
Clay Grey	83			

Engineer H. A. Stahl, PE

Hole 8 "Dia Drilled by: { Cable Tool x Rotary ____ Jetting ____ / Reverse Circ. ____ Bucket ____ Auger ____

Rotary Hole Grouted: Neat Cement ____ Drilling Mud ____ Other ____

Casing 8 "OD From 12 "above ground to 63 feet below ground. Weight ____ Pounds per f

Screen 8 " Set from 63 to 83 feet Make Johnson Type SS Slot 12

Pumping test 226 GPM drawdown to 48 feet after 4 hours pumping

Date Completed 7/7/70 Driller Dick Kent

0550

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION

WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978
Failure to comply is a misdemeanor

TAX NO: 28-13-109-018-01

PERMIT NO: 27250

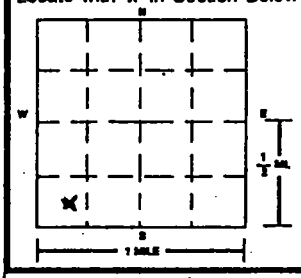
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
GRAND TRAVERSE	WHITEWATER	SE 1/4 SW 1/4 SW 1/4	9	28N	9W

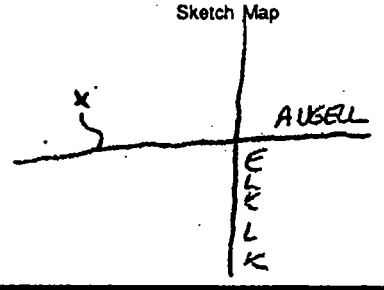
Distance and Direction from Road Intersection: W. off Elk Lake Rd, N. side of Angell Rd. HOUSE WELL

Street Address & City of Well Location: 8255 ANGELL RD

Locate with 'x' in Section Below



Sketch Map



3. OWNER OF WELL: CHRIS AND JANET HUBBELL
Address: 10190 MUNRO RD
WILLIAMSBURG MI 49690
Address Same as Well Location ☐ Yes ☒ No

4. WELL DEPTH: 155 ft. Date Completed: 5-26-00 ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐ _____

6. USE: ☒ Household ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐ _____

7. CASING: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded ☐ Other _____
Diameter: _____ in. to _____ ft. depth
5 in. to 147 ft. depth
BORE HOLE:
Diameter: 6 1/4 in. to 155 ft. depth
Height: Above/Below Surface: 1 ft
Weight: SDR21 lbs./ft.
☐ Drive Shoe ☐ Shale Packer

8. SCREEN: ☐ Not Installed ☐ Gravel-Packed
Type PVC Diameter 4"
Slot/Gauze 10 Length: 8'
Set Between 147' ft. and 155' ft.
FITTINGS: ☒ K-Packer ☐ Bremer Check ☒ Blank Above Screen 2 ft. Other _____

9. STATIC WATER LEVEL: 60 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface
_____ ft. After 1/2 hrs. Pumping at 18 G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION:
☒ Pitless Adapter ☒ 12" Above Grade ☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 0 to 137 ft.
☐ Neat Cement ☐ Bentonite ☒ Other VOLCLAY
No. of Bags 6 Additives _____

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type SEPTIC Distance 50 ft. Direction _____
Type _____ Distance _____ ft. Direction _____

14. PUMP: ☐ Not Installed ☒ Pump Installation Only
Manufacturer's Name RED JACKET
Model Number 150F3111CNS8CC HP 1.5 Volts 230
Length of Drop Pipe 143' ft. Capacity 18 G.P.M.
TYPE: ☒ Submersible ☐ Jet ☐ Other _____
PRESSURE TANK: 1 1/4" GALV DROP
Manufacturer's Name WELL ENVIRON
Model Number WX 350 Capacity 119 Gallons

2. FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND	20	20
SAND - CLAY	22	42
CLAY	16	58
SAND	7	65
CLAY	69	134
SAND	21	155

USE A 2ND SHEET IF NEEDED

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter _____ in. Depth _____ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry ☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags _____ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)
House Well

17. DRILLING MACHINE OPERATOR:
☒ Employee ☐ Subcontractor
Name: Douglas Schettek

RECEIVED JUN 09 2000

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
HILO WELL DRILLING, INC. 6481
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 3783 Rennie School Rd. Traverse City MI
Signed Philip Shamrowski Date 6-07-00
AUTHORIZED REPRESENTATIVE

LOCAL HEALTH DEPT. COPY

EQP 2017 (12/96)

GEOLOGICAL SURVEY SAMPLE No.

WATER WELL RECORD

ACT 294 · PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

9-8

1 LOCATION OF WELL

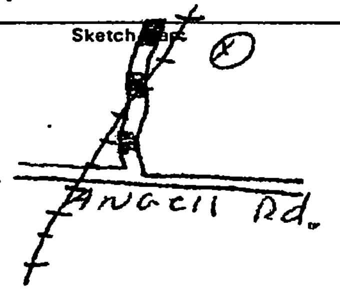
County	Township Name	Fraction	Section Number	Town Number	Range Number
Grand Traverse	Whitewater	NW¼ SW¼	9	28 N/S.	9 E/W.

Distance And Direction from Road Intersections: 1/2 mile north of Angell Rd. on Monroe Rd.

Street address & City of Well Location

Locate with "X" in section below: X (1 MILE, ½ MI.)

Sketch Map:



3 OWNER OF WELL: Keith Hubbel

Address: R#2 Williamsburg, Elk Rapids, Mich

4 WELL DEPTH: (completed) 99 ft. Date of Completion 9-14-77

5 [x] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [x] Bored [ ]

6 USE: [ ] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [ ]

7 CASING: Threaded [x] Welded [ ]
Diam. 4 in. to 89 ft. Depth; ___ in. to ___ ft. Depth
Height: Above/Below Surface 1 ft.
Weight 11 lbs./ft.
Drive Shoe? Yes [x] No [ ]

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay - sand - stone	32	32
Fine water sand - Clay	34	66
Clay - water sand	12	78
water sand	21	99

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type: S.S. Dia.: 4"
Slot/Gauze .010 Length 10'
Set between 89 ft. and 99 ft.
Fittings:

9 STATIC WATER LEVEL 50 ft. below land surface

10 PUMPING LEVEL below land surface
___ ft. after ___ hrs. pumping ___ g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ___ Chlorides (Cl) ___
Hardness ___ Other ___

12 WELL HEAD COMPLETION: [ ] In Approved Pit [x] Pitless Adapter [x] 12" Above Grade

13 Well Grouted? [x] Yes [ ] No
[ ] Neat Cement [x] Bentonite [x] sand
Depth: From ___ ft. to ___ ft.

14 Nearest Source of possible contamination
50 feet ___ Direction septic Type
Well disinfected upon completion [x] Yes [ ] No

15 PUMP: [ ] Not installed
Manufacturer's Name F&W
Model Number 3DFC7 HP 3 Volts 230
Length of Drop Pipe 20 ft. capacity 25 G.P.M.
Type: [x] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Phil's Well Drilling 2481
REGISTERED BUSINESS NAME · REGISTRATION NO.

Address 10725 Grandview Pl. Rd. #1

Signed [signature] Date 9-21-77
AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No.

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

9-C

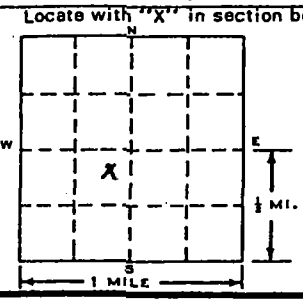
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	NE ¼ NE ¼ SW ¼	7	28 N/S.	9 E/W.

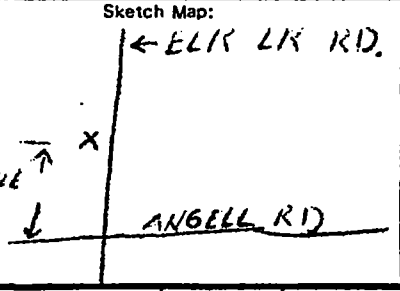
Distance And Direction from Road Intersections
½ MILE NORTH OF ANGELL RD ON ELK LK. RD.

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL:
Address MIKE PARADIS
WILLIAMSBURG

4 WELL DEPTH: (completed) Date of Completion
143 ft. 6-77

5 ☒ Cable tool ☒ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☐ Domestic ☐ Public Supply ☐ Industry
☒ Irrigation ☐ Air Conditioning ☐ Commercial
☐ Test Well ☐ ____

7 CASING: Threaded ☐ Welded ☒ Diam.
6 in. to 128 ft. Depth
____ in. to ____ ft. Depth
Height: Above/Below Surface 1 ft.
Weight 18.12 lbs./ft.
Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SANDY CLAY	12	12
CLAY	58	70
SAND	73	143

8 SCREEN:
Type: STAINLESS Dia.: 6" NOM.
Slot/Gauze 12 Length 15'
Set between 128 ft. and 143 ft.
Fittings: K. PAKER + NECK

9 STATIC WATER LEVEL
87 ft. below land surface

10 PUMPING LEVEL below land surface
____ ft. after ____ hrs. pumping ____ g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit
☐ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No
☐ Neat Cement ☐ Bentonite ☐ ____
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination
____ feet ____ Direction ____ Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed
Manufacturer's Name GOULDS
Model Number ____ HP 7.5 Volts 460
Length of Drop Pipe 120 ft. capacity 15 G.P.M.
Type: ☒ Submersible
☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

McPHERSON'S
REGISTERED BUSINESS NAME

0672
REGISTRATION NO.

Address KEWADIN, MICH

Signed [signature] AUTHORIZED REPRESENTATIVE Date 1-26-78

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

GEOLOGICAL SURVEY NO. 09-003

WATER WELL AND PUMP RECORD

28-13-109-017-10

PERMIT NUMBER 17656 (9-1

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Grand Traverse	Whitewater	SE ¼ NE ¼ SW ¼	9	28 N/S	9 E/W

Distance And Direction From Road Intersection: Approx ¼ mile north of Angell Rd on Elk Lk Rd west side.

Street Address & City of Well Location: 10347 Elk Lk Rd

Locate with "X" in Section Below — Sketch Map: 10347; Angell Rd; Elk Lk Rd

1 MILE; ½ MI.

3 OWNER OF WELL: Jacqueline D Smith

Address 10347 Elk Lk Rd

Address Same As Well Location? [x] Yes [ ] No

4 WELL DEPTH: 162 FT. Date Completed: MO. 6 DAY 29 YEAR 89 — [x] New Well [ ] Replacement Well

5 [ ] Cable tool [x] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Auger [ ] Jetted [ ]

6 USE: [x] Domestic [ ] Type I Public [ ] Type III Public [ ] Irrigation [ ] Type IIa Public [ ] Heat pump [ ] Test Well [ ] Type IIb Public [ ]

7 CASING: Diameter [ ] Steel [ ] Threaded [x] Plastic [ ] Welded

5 in. to 158 ft. depth

___ in. to ___ ft. depth

Grouted Drill Hole Diameter 7⅞ in. to ___ ft. depth; ___ in. to ___ ft. depth

Height: Above/Below Surface ___ ft. Weight ___ lbs./ft. Drive Shoe [ ] Yes [ ] No

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	30	30
Clay + gravel	77	107
Clay & sand/gr.	37	144
Water sand	18	162

USE A 2ND SHEET IF NEEDED

8 SCREEN: [ ] Not Installed

Type Stainless Diameter 4

Slot/Gauze 12 Length 4

Set between ___ ft. and ___ ft.

FITTINGS: [x] K-Packer [ ] Lead Packer [ ] Bremer Check

[ ] Blank above screen 2 ft. Other

9 STATIC WATER LEVEL: 216 M

90 ft. below land surface [ ] Flow

10 PUMPING LEVEL: below land surface

120 ft. after 1 hrs. pumping at 35 G.P.M.

___ ft. after ___ hrs. pumping at ___ G.P.M.

11 WELL HEAD COMPLETION: [x] Pitless adapter [ ] 12" above grade [ ] Basement offset [ ] Approved pit

12 WELL GROUTED? [ ] No [x] Yes From 0 to 90 ft.

[ ] Neat cement [x] Bentonite [ ] Other Drl Mud

No. of bags of cement ___ Additives ___

13 Nearest source of possible contamination

Type Septic Distance 60 ft. Direction W

Well disinfected upon completion? [x] Yes [ ] No

Was old well plugged? [ ] Yes [ ] No

14 PUMP: [ ] Not Installed [ ] Pump Installation Only

Manufacturer's name Flint & Walling

Model number 4F10405 HP ½ Volts 230

Length of Drop Pipe 120 ft. capacity 10 G.P.M.

TYPE: [x] Submersible [ ] Jet

PRESSURE TANK:

Manufacturer's name Wellxtrol

Model number 203 Capacity 32 Gallons

15. Remarks, elevation, source of data, etc.

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

[signature] REGISTERED BUSINESS NAME — REGISTRATION NO. 28-1241

Address 6411 ... Traverse City, MI

Signed [signature] AUTHORIZED REPRESENTATIVE Date 6-29-89

17. Rig Operator's Name: Ken [illegible]

D67d 12/85

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

RECEIVED AUG 0 8 1989

LOCAL HEALTH DEPT. COPY

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION

WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978
Failure to comply is a misdemeanor

(4) (9-

TAX NO: 28-13-109-017-00

PERMIT NO: 27047

1. LOCATION OF WELL

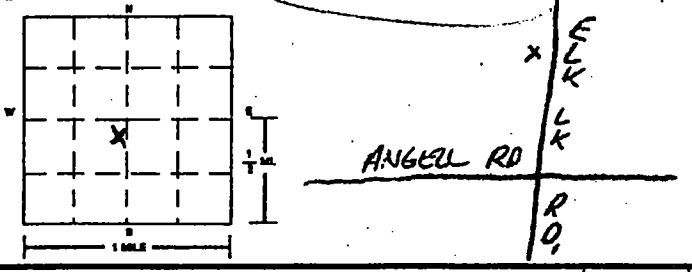
County	Township Name	Fraction	Section No.	Town No.	Range No.
GRAND TRAVERSE	WHITEWATER	NE 1/4 NE 1/4 SW 1/4	9	28 N	9W

Distance and Direction from Road Intersection

Street Address & City of Well Location 10329 ELK LK RD.

Locate with 'x' in Section Below

Sketch Map



3. OWNER OF WELL ROBBIN BUSTANCE
Address 10329 ELK LAKE RD
WILLIAMSBURG MI 49690
Address Same as Well Location [X] Yes [ ] No

4. WELL DEPTH: 173 ft. Date Completed 8 27 99 [ ] New Well [X] Replacement Well

5. [ ] Cable Tool [X] Rotary [ ] Driven [ ] Dug [ ] Hollow Rod [ ] Auger/Bored [ ] Jetted [ ]

6. USE: [X] Household [ ] Type I Public [ ] Type III Public [ ] Irrigation [ ] Type IIa Public [ ] Heat Pump [ ] Test Well [ ] Type IIb Public [ ]

7. CASING: [ ] Steel [ ] Threaded [X] Plastic [ ] Welded [ ] Other
Diameter: 5 in. to 165 ft. depth
in. to ft. depth
BORE HOLE: Diameter: 7 7/8 in. to 173 ft. depth
in. to ft. depth
Height: Above/Below Surface: 1 ft
Weight: SDR 21 lbs./ft.
[ ] Drive Shoe [ ] Shale Packer

8. SCREEN: [ ] Not Installed [X] Gravel-Packed
Type Johnson pvc Diameter 4"
Slot/Gauze 15 Length: 8'
Set Between 165 ft. and 173 ft.
FITTINGS: [X] K-Packer [ ] Bremer Check
[ ] Blank Above Screen 2 ft. Other

9. STATIC WATER LEVEL: 40 ft. Below Land Surface [ ] Flowing

10. PUMPING LEVEL: Below Land Surface
ft. After hrs. Pumping at G.P.M.
[ ] Plunger [ ] Bailer [X] Air [ ] Test Pump

11. WELL HEAD COMPLETION:
[X] Pitless Adapter [ ] 12" Above Grade
[ ] Basement Offset [ ] Well House

12. WELL GROUTED? [ ] No [X] Yes From 0 to 155 ft
[ ] Neat Cement [ ] Bentonite [X] Other grout well
No. of Bags 10 Additives

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type Septic Distance 60 ft. Direction S
Type Distance ft. Direction

14. PUMP: [ ] Not Installed [X] Pump Installation Only
Manufacturer's Name Jacuzzi
Model Number J754108B HP 3/4 Volts 230
Length of Drop Pipe 120 ft. Capacity 10 G.P.M.
TYPE: [X] Submersible [ ] Jet [ ] Other
PRESSURE TANK:
Manufacturer's Name
Model Number Capacity Gallons

2. FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand / few stones	10	10
Hard clay	14	24
Sand	8	32
Hard clay	8	40
Sand	30	70
Hard clay	58	128
Sand / clay	3	131
Hard clay	33	164
Sand	9	173

USE A 2ND SHEET IF NEEDED

15. ABANDONED WELL PLUGGED? [X] Yes [ ] No
Casing Diameter 4 in. Depth 147 ft.
PLUGGING MATERIAL: [ ] Neat Cement [X] Bentonite Slurry [ ] Cement/Bentonite Slurry [ ] Concrete Grout [ ] Bentonite Chips
No. of Bags 9 Casing Removed? [ ] Yes [X] No

16. REMARKS: (Elevation, Source of Data, etc.)

17. DRILLING MACHINE OPERATOR:
[X] Employee [ ] Subcontractor
Name Greg Kilinski

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Cliff Well Drilling Company 28-1244
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 6410 Center Rd. Traverse City, MI 49686
Signed D. Kilinski Date 8/27/99
AUTHORIZED REPRESENTATIVE

RECEIVED SEP 13 1999

LOCAL HEALTH DEPT. COPY

EQP 2017 (12/96)

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

GEOLOGICAL SURVEY NO.

WATER WELL AND PUMP RECORD

PERMIT NUMBER 116448

9-1

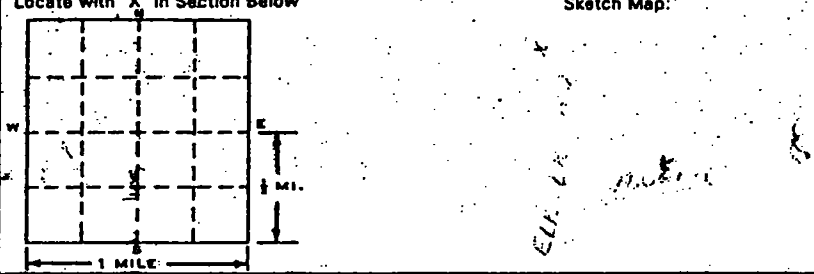
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Grand Traverse	Whitewater	SW 1/4 NW 1/4 SW 1/4	9	27 N/S	9 E/W

Distance And Direction From Road Intersection: Approx 1/4 mi ... Angell Rd on Elk Lk Rd on the west side

Street Address & City of Well Location:

Locate with "X" in Section Below — Sketch Map:



2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	3
Clay	3	65
Clay & Rocks	65	93
Sand & Rocks	93	115
Clay	115	156
Rocks & silt	156	167
Sand	167	173

RECEIVED

JAN 02 1990

GRAND TRAVERSE-LEELANAU DISTRICT HEALTH DEPT.

18016

USE A 2ND SHEET IF NEEDED

3 OWNER OF WELL: Billy D Smith

Address: 9469 Elk Lk Rd

Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH: 173 FT.

Date Completed: MO. 10 DAY 19 YEAR 89

☒ New Well ☐ Replacement Well

5

☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug

☐ Hollow rod ☐ Auger ☐ Jetted ☐

6 USE:

☒ Domestic ☐ Type I Public ☐ Type III Public

☐ Irrigation ☐ Type IIa Public ☐ Heat pump

☐ Test Well ☐ Type IIb Public ☐

7 CASING:

Diameter: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded

5" in. to ___ ft. depth

___ in. to 173 ft. depth

Drill Hole Diameter

___ in. to ___ ft. depth

8 in. to 173 ft. depth

Height: Above/Below Surface ___ ft.

Weight SDR 21

Drive Shoe ☐ Yes ☐ No

8 SCREEN:

☐ Not Installed

Type PVC Diameter 4"

Slot/Gauze 10 Length 5 ft

Set between 168 ft. and 173 ft.

FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check

☐ Blank above screen ___ ft. Other ___

9 STATIC WATER LEVEL:

60 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface

___ ft. after ___ hrs. pumping at ___ G.P.M.

___ ft. after ___ hrs. pumping at ___ G.P.M.

11 WELL HEAD COMPLETION:

☒ Pitless adapter ☐ 12" above grade

☐ Basement offset ☐ Approved pit

12 WELL GROUTED?

☐ No ☒ Yes From ___ to ___ ft.

☐ Neat cement ☐ Bentonite ☒ Other Wet clay

No. of bags of cement ___ Additives ___

13 Nearest source of possible contamination

Type septic Distance 50 ft. Direction ___

Well disinfected upon completion? ☒ Yes ☐ No

Was old well plugged? ☐ Yes ☐ No

14 PUMP:

☐ Not Installed ☐ Pump Installation Only

Manufacturer's name Red Jacket

Model number 2 HP 3/4 Volts 230

Length of Drop Pipe 100 ft. capacity 10 G.P.M.

TYPE: ☒ Submersible ☐ Jet ___

PRESSURE TANK:

Manufacturer's name Well Extrol

Model number WX 203 Capacity 80 Gallons

15. Remarks, elevation, source of data, etc.

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Phil's Well Drilling 0481

REGISTERED BUSINESS NAME — REGISTRATION NO.

Address 10795 Grand View Rd T.C.

Signed Phil Sharnowski Date 10/20/89

AUTHORIZED REPRESENTATIVE

17. Rig Operator's Name:

Doug Schettek

D67d 12/85

Authority: Act 368 PA 1978

Completion: Required

Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

GEOLOGICAL SURVEY NO. 09-004

WATER WELL AND PUMP RECORD

28-13-109-008-00

PERMIT NUMBER 1/9/13/6 (9-13)

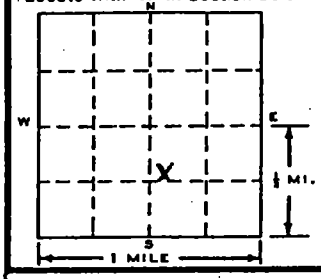
1. LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	SW. NW. SE. 1/4	9	28 N/S	9 E/W

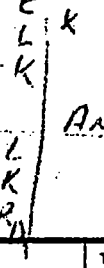
Distance And Direction From Road Intersection: APPROX 1/4 MILE NORTH OF ANGELL RD ON ELK LK RD

Street Address & City of Well Location: 10260 ELK LK RD

Locate with "X" in Section Below



Sketch Map:



3. OWNER OF WELL

DON HANNON

Address 10260 ELK LK RD WILLIAMSBURG MI

Address Same As Well Location? [X] Yes [ ] No

4. WELL DEPTH

149 FT.

Date Completed: MO. 8 DAY 14 YEAR 90

[ ] New Well [X] Replacement Well

5

[ ] Cable tool [X] Rotary [ ] Driven [ ] Dug

[ ] Hollow rod [ ] Auger [ ] Jetted [ ]

6 USE

[X] Domestic [ ] Type I Public [ ] Type III Public

[ ] Irrigation [ ] Type IIa Public [ ] Heat pump

[ ] Test Well [ ] Type IIb Public [ ]

7 CASING

Diameter: [ ] Steel [ ] Threaded [X] Plastic [ ] Welded

5 in. to 144 ft. depth

in. to ft. depth

Grouted Drill Hole Diameter: 7 7/8 in. to 149 ft. depth

in. to ft. depth

Height: Above/Below Surface 1 ft.

Weight SDR 21 lbs./ft.

Drive Shoe [ ] Yes [X] No

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Topsoil and Sand	33	33
Red clay	15	48
Gravel-sand	29	77
Sand	13	90
Gravel-sand	22	112
Clay-gravel-sand	13	125
Sand	24	149
Sand on the bottom	?	

USE A 2ND SHEET IF NEEDED

8 SCREEN

[ ] Not Installed

Type pvc Diameter 3"

Slot/Gauge 30 Length 5'

Set between 144 ft. and 149 ft.

FITTINGS: [X] K-Packer [ ] Lead Packer [ ] Bremer Check

[X] Blank above screen 2 ft. Other

9 STATIC WATER LEVEL

97' 214 M ft. below land surface [ ] Flow

10 PUMPING LEVEL: below land surface

ft. after hrs. pumping at G.P.M.

ft. after hrs. pumping at G.P.M.

11 WELL HEAD COMPLETION

[X] Pitless adapter [ ] 12" above grade

[ ] Basement offset [ ] Approved pit

12 WELL GROUTED?

[ ] No [X] Yes From 0 to 30 ft.

[ ] Neat cement [ ] Bentonite [X] Other Vol-plug

No. of bags of cement Additives

13 Nearest source of possible contamination

Type Septic Distance 70+ ft. Direction north

Well disinfected upon completion? [X] Yes [ ] No

Was old well plugged? [X] Yes [ ] No

14 PUMP

[ ] Not Installed [ ] Pump Installation Only

Manufacturer's name Bett-a-flo

Model number 12 gpm HP 1 Volts 230

Length of Drop Pipe 120 ft. capacity 12 G.P.M.

TYPE: [X] Submersible [ ] Jet

PRESSURE TANK:

Manufacturer's name

Model number Capacity Gallons

15. Remarks, elevation, source of data, etc.

* WELL TO BE CHECKED FOR NITRATES PRIOR TO COMPLETION

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Kropp Well Drilling, Inc. 0795

REGISTERED BUSINESS NAME REGISTRATION NO.

Address 6010 West M-72 Traverse City, MI 4968

Signed AUTHORIZED REPRESENTATIVE Date August 15, 19

17. Rig Operator's Name:

Dale Kropp

D67d 2/89

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

09+010

TAX NO: 28 13-11-9-022-10

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER WELL AND PUMP RECORD

PERMIT NO: GT 24455 (9-14)

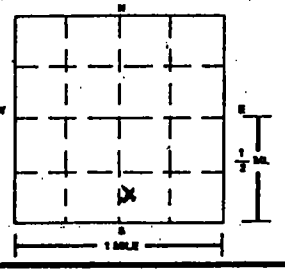
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
Grand Traverse	Whitewater	NW 1/4 SW 1/4 SE 1/4	9	28 N	9 W

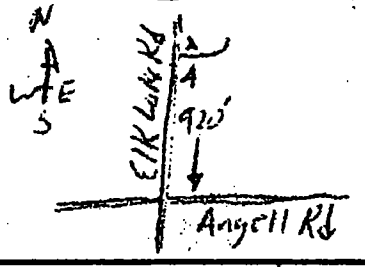
Distance and Direction from Road Intersection: 10192 Elk Lake Rd (Parcel ID) Across off east side 920' north of Angell Rd ~~Williamsburg~~

Street Address & City of Well Location: 10192

Locate with 'x' in Section Below



Sketch Map



3. OWNER OF WELL
Address: Sunrise Solar, 7520 Cairn Hwy, Elk Rapids, MI 49629
Address Same as Well Location: ☐ Yes ☐ No

4. WELL DEPTH: 144 ft. Date Completed 11/5/97 ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐ ____

6. USE: ☒ Household ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐ ____

7. CASING: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded ☐ Other ____
Diameter: 5 in. to 140 ft. depth; ____ in. to ____ ft. depth
BORE HOLE: Diameter: 8 in. to 144 ft. depth; ____ in. to ____ ft. depth
Height: Above/Below Surface: ____ ft
Weight: ____ lbs./ft.
☐ Drive Shoe ☐ Shale Packer

8. SCREEN: ☐ Not Installed ☒ Gravel-Packed
Type STAINLESS Diameter ____
Slot/Gauze 20 Length: ____
Set Between ____ ft. and ____ ft.
FITTINGS: ☒ K-Packer ☐ Bremer Check ☐ Blank Above Screen 6" ft. Other ____

9. STATIC WATER LEVEL: 217m
90 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface
90 ft. After 2 hrs. Pumping at 40 G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION:
☒ Pitless Adapter ☐ 12" Above Grade ☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 0 to 130 ft.
☐ Neat Cement ☒ Bentonite ☐ Other ____
No. of Bags 7 Additives EZ MUD

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type SEPTIC Distance 75 ft. Direction E
Type ____ Distance ____ ft. Direction ____

14. PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's Name F.W.
Model Number ____ HP 1/2 Volts 220
Length of Drop Pipe 120 ft. Capacity 10 G.P.M.
TYPE: ☒ Submersible ☐ Jet ☐ Other ____
PRESSURE TANK:
Manufacturer's Name WEL RITE
Model Number WR 140 Capacity ____ Gallons ____

2. FORMATION DESCRIPTION

	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
17 CLAY, GRAVEL	30	30
25 SAND & GRAVEL	20	50
30 GRAVEL	60	110
17 GREY CLAY & GRAVEL	8	118
20 SAND	26	144

USE A 2ND SHEET IF NEEDED

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter ____ in. Depth ____ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry ☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags ____ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)

17. DRILLING MACHINE OPERATOR:
☒ Employee ☐ Subcontractor
Name CHUCK MCPHERSON

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
McPHERSON & SONS 0672
REGISTERED BUSINESS NAME REGISTRATION NO.
Address KEWADIN
Signed [signature] AUTHORIZED REPRESENTATIVE Date 11-10-97

GW-2-228 9/93

RECEIVED DEC 29 1997

LOCAL HEALTH DEPT. COPY

Authority: Act 368 PA 1978 Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

X-097-009

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER WELL AND PUMP RECORD

TAX NO: 28-13-114022-10

PERMIT NO: GT-24546 (9-15)

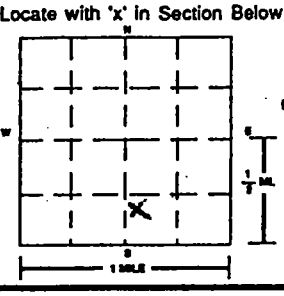
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
Grand Traverse	White Water N	NW 1/4 Sec 1/4 SE 1/4	9	28	9

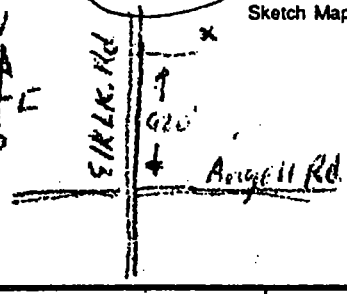
Distance and Direction from Road Intersection: 10176 Elk Lake Rd (Route 13) Access East side 920' North of Angell Rd. Williamsburg

Street Address & City of Well Location: (10176)

Locate with 'x' in Section Below



Sketch Map



3. OWNER OF WELL: Sunrise Solar - Tillman Bird
Address: 7520 Cairn Hwy, Elk Rapids MI 49629
Address Same as Well Location ☐ Yes ☒ No

4. WELL DEPTH: 141 ft. Date Completed: 5-19-97 ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐ _____

6. USE: ☒ Household ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐ _____

7. CASING: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded ☐ Other _____
Diameter: 5 in. to 139 ft. depth; 5 in. to ft. depth
BORE HOLE: Diameter: 7 7/8 in. to 147 ft. depth; in. to ft. depth
Height: Above/Below Surface: _____ ft
Weight: _____ lbs./ft.
☐ Drive Shoe ☐ Shale Packer

8. SCREEN: ☐ Not Installed ☒ Gravel-Packed
Type Johnson PVC Diameter 4"
Slot/Gauge 15 Length: 8
Set Between 139 ft. and 147 ft.
FITTINGS: ☒ K-Packer ☐ Bremer Check ☐ Blank Above Screen 2 ft. Other _____

9. STATIC WATER LEVEL: 217M 84 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface
_____ ft. After _____ hrs. Pumping at 30 G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION:
☒ Pitless Adapter ☐ 12" Above Grade ☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 0 ft. to 139 ft.
☐ Neat Cement ☐ Bentonite ☒ Other Grout
No. of Bags 7 Additives _____

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type Septic Distance 50' ft. Direction N.W
Type _____ Distance _____ ft. Direction _____

2. FORMATION DESCRIPTION

		THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
19	Sand/gravel/clay	25	25
32	Gravel/sand/stone	10	35
25	sand/gravel	78	113
10	clay	1	114
25	sand/gravel	33	147

USE A 2ND SHEET IF NEEDED

14. PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's Name Myers
Model Number 25T7P12 HP 3/4 Volts 230
Length of Drop Pipe 120 ft. Capacity 12 G.P.M.
TYPE: ☒ Submersible ☐ Jet ☐ Other _____
PRESSURE TANK:
Manufacturer's Name well-rite
Model Number 1 40 Capacity _____ Gallons 44

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter _____ in. Depth _____ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry ☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags _____ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)

17. DRILLING MACHINE OPERATOR:
☒ Employee ☐ Subcontractor
Name Greg Kolenski

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Cliff Well Drilling Co. 28-1244
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 6410 Center Rd. Traverse City, Mi. 49684
Signed Gregory J. Kolenski Date 5-28-97
AUTHORIZED REPRESENTATIVE

GW-2-228 9/93

RECEIVED JUN 02 1997

LOCAL HEALTH DEPT. COPY

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

GEOLOGICAL SURVEY NO. 09-005

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

28-13-109-022-00

PERMIT NUMBER 18582 (9-1)

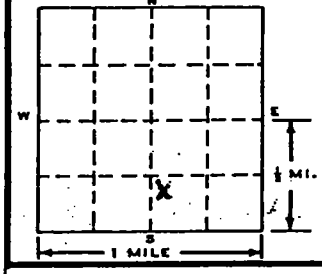
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	N½ SW SE ¼	9	28 N/S	9 E/W

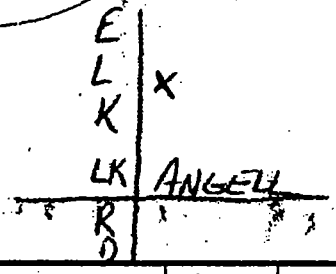
Distance And Direction From Road Intersection: APPROX ¼ MILE NORTH OF ANGELL RD ON ELK LAKE RD EAST SIDE

Street Address & City of Well Location: 10144 ELK LK RD

Locate with "X" in Section Below



Sketch Map:



3 OWNER OF WELL: CHARLES E. GRACE

Address: 10144 ELK LAKE RD

Address Same As Well Location? [X] Yes [ ] No

4 WELL DEPTH: 145 FT.

Date Completed: MO. 7 DAY YEAR 90

[X] New Well [X] Replacement Well

5

[ ] Cable tool [X] Rotary [ ] Driven [ ] Dug
[ ] Hollow rod [ ] Auger [ ] Jetted [ ]

6 USE:

[X] Domestic [ ] Type I Public [ ] Type III Public
[ ] Irrigation [ ] Type IIa Public [ ] Heat pump
[ ] Test Well [ ] Type IIb Public [ ]

7 CASING:

Diameter: [ ] Steel [ ] Threaded [X] Plastic [ ] Welded

5 in. to 141 ft. depth

____ in. to ____ ft. depth

Grouted Drill Hole Diameter: 8 in. to 25 ft. depth

____ in. to ____ ft. depth

Height: Above/Below Surface 1 ft.

Weight ____ lbs./ft.

Drive Shoe [ ] Yes [X] No

2 FORMATION DESCRIPTION

	FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
27	SAND + CLAY	30	30
7	CLAY + GRAVEL	20	50
27	SAND + CLAY	26	76
15	SAND + GRAVEL	15	91
1	GRAY CLAY	35	126
20	SAND	19	145

USE A 2ND SHEET IF NEEDED

8 SCREEN:

[ ] Not Installed

Type STAINLESS Diameter 4"

Slot/Gauge 12 Length 4'

Set between 141 ft. and 145 ft.

FITTINGS: [X] K-Packer [ ] Lead Packer [ ] Bremer Check

[ ] Blank above screen 1 ft. Other ____

9 STATIC WATER LEVEL:

90 ft. below land surface 216

[ ] Flow

10 PUMPING LEVEL: below land surface

90 ft. after 1 hrs. pumping at 40 G.P.M.

____ ft. after ____ hrs. pumping at ____ G.P.M.

11 WELL HEAD COMPLETION:

[X] Pitless adapter [ ] 12" above grade
[ ] Basement offset [ ] Approved pit

12 WELL GROUTED?

[ ] No [X] Yes From 0 to 140 ft.

[ ] Neat cement [X] Bentonite [ ] Other ____

No. of bags of cement ____ Additives ____

13 Nearest source of possible contamination

Type SEPTIC Distance 75 ft. Direction NE

Well disinfected upon completion? [X] Yes [ ] No

Was old well plugged? [X] Yes [ ] No

14 PUMP:

[ ] Not Installed [ ] Pump Installation Only

Manufacturer's name ____

Model number ____ HP ¾ Volts 220

Length of Drop Pipe 140 ft. capacity 10 G.P.M.

TYPE: [X] Submersible [ ] Jet ____

PRESSURE TANK:

Manufacturer's name EXTROL

Model number 203 Capacity ____ Gallons

15. Remarks, elevation, source of data, etc.

DEC - 4 1990

GRAND TRAVERSE COUNTY HEALTH DEPARTMENT

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

McPHERSON + SONS 0672

REGISTERED BUSINESS NAME REGISTRATION NO.

Address KEWADIN

Signed Charles McPherson Date 12-10-90

AUTHORIZED REPRESENTATIVE

17. Rig Operator's Name:

RAY MERCHANT

D67d 2/89

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY NO. 09-006

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

28-013-109-021-00

PERMIT NUMBER 92047 (9-)

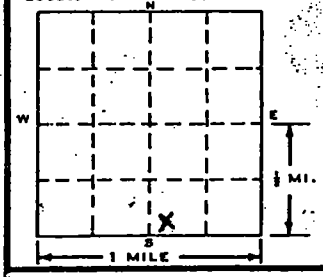
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	SW¼ SW¼ SE¼	9	28 N/S	9 E/W

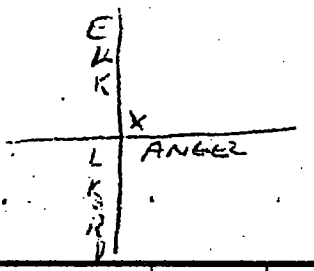
Distance And Direction From Road Intersection: NE CORNER OF ANGER AND ELK LK RD INTERSECTION

Street Address & City of Well Location: 8533 Angen Rd ELK LK RD

Locate with "X" in Section Below



Sketch Map:



3 OWNER OF WELL

PAUL R GAMBLE

Address: P.O BOX 11 NEW HUDSON MI

Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH

168 FT. Date Completed MO. 6 DAY 19 YEAR 92 ☒ New Well ☐ Replacement Well

5

☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Auger ☐ Jetted ☐ ____

6 USE

☒ Domestic ☐ Type I Public ☐ Type III Public
☐ Irrigation ☐ Type IIa Public ☐ Heat pump
☐ Test Well ☐ Type IIb Public ☐ ____

7 CASING

Diameter: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded

1 ½ in. to ____ ft. depth
____ in. to 168 ft. depth
Drilled Drill Hole Diameter
7⅞ in. to ____ ft. depth
____ in. to 168 ft. depth

Height: Above/Below
Surface 1 ft.
Weight SDR 15.5 PV

Drive Shoe ☐ Yes ☐ No

8 SCREEN

☐ Not Installed
Type PVC Diameter 4"
Slot/Gauze 10 Length 8FT
Set between 160 ft. and 168 ft.
FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check
☒ Blank above screen ____ ft. Other ____

9 STATIC WATER LEVEL

215 M
100 Ft. ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface

____ ft. after ____ hrs. pumping at ____ G.P.M.
____ ft. after ____ hrs. pumping at ____ G.P.M.

11 WELL HEAD COMPLETION

☒ Pitless adapter ☒ 12" above grade
☐ Basement offset ☐ Approved pit

12 WELL GROUTED?

☐ No ☒ Yes From 0 to 25 ft.
☐ Neat cement ☒ Bentonite ☒ Other Volclay
No. of bags of cement ____ Additives ____

13 Nearest source of possible contamination

Type Septic Distance 50 + ft. Direction ____
Well disinfected upon completion? ☒ Yes ☐ No
Was old well plugged? ☐ Yes ☐ No

14 PUMP

☐ Not Installed ☐ Pump Installation Only
Manufacturer's name Myers
Model number Z-GV HP 3/4 Volts 230
Length of Drop Pipe 120 ft. capacity 12 G.P.M.
TYPE: ☒ Submersible ☐ Jet
PRESSURE TANK:
Manufacturer's name Well-Xtrol
Model number WX-203 Capacity Pressure Tank gallons

2 FORMATION DESCRIPTION

	FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
7	Sand & Clay	30	30
3	Gravel	35	65
1	Clay	15	80
0	Sand	55	135
3	Clay	15	150
29	Sand (water)	18	168

Dg# 92-228870

RECEIVED AUG 10 1992

15. Remarks: elevation, source of data, etc.

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Phillips Well Drilling 0481
REGISTERED BUSINESS NAME REGISTRATION NO.

Address 3783 Keyes Rd. Traverse City

Signed [signature] Date 6/23/92
AUTHORIZED REPRESENTATIVE

17. Rig Operator's Name

DAVE MCGOWAN

D67d 2/89

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY NO.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

PERMIT NUMBER 1-0786

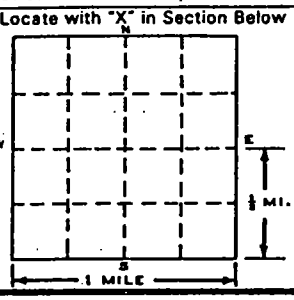
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	SE¼ SE¼ SE¼	8	28 N/S	9 E/W

Distance And Direction From Road Intersection: CORNER & MUNRO Rd. (NW)

Street Address & City of Well Location:

Locate with "X" in Section Below



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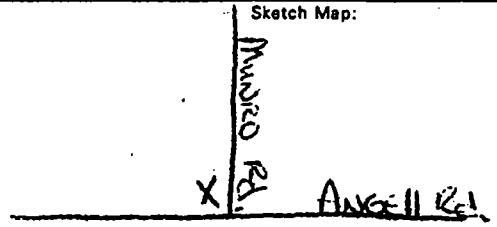


3 OWNER OF WELL:

CLARENCE BOALS

Address: R#2 WILLIAMSBURG, MI.

Address Same As Well Location? ☑ Yes ☐ No

4 WELL DEPTH: (completed)

49 ft.

Date of Completion: 7-3-84

5

☐ Cable tool ☑ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Auger ☐ Jetted ☐ _____

6 USE:

☑ Domestic ☐ Type I Public ☐ Type III Public
☐ Irrigation ☐ Type IIa Public ☐ Heat pump
☐ Test Well ☐ Type IIb Public ☐ _____

7 CASING:

Diameter: ☐ Steel ☐ Threaded ☑ Plastic ☐ Welded

5 in. to 44 ft. depth

_____ in. to _____ ft. depth

Grouted Drill Hole Diameter

_____ in. to _____ ft. depth

_____ in. to _____ ft. depth

Height: Above/Below Surface 1 ft.

Weight .3 lbs./ft.

Drive Shoe ☐ Yes ☑ No

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND	0	28
CLAY & SAND	28	44
WATER SAND	44	49

8 SCREEN:

☐ Not Installed

Type PLASTIC Diameter 4"

Slot/Gauze .10 Length 5'

Set between 49 ft. and 49 ft.

FITTINGS: ☑ K-Packer ☐ Lead Packer ☐ Bremer Check

☐ Blank above screen 2 ft. Other _____

9 STATIC WATER LEVEL:

5 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface

_____ ft. after _____ hrs. pumping at _____ G.P.M.

_____ ft. after _____ hrs. pumping at _____ G.P.M.

11 WELL HEAD COMPLETION:

☑ Pitless adapter ☑ 12" above grade
☐ Basement offset ☐ Approved pit

12 WELL GROUTED?

☐ No ☑ Yes From _____ to _____ ft.

☐ Neat cement ☑ Bentonite ☐ Other SAND

No. of bags of cement _____ Additives _____

13 Nearest source of possible contamination

Type SEPTIC Distance _____ ft. Direction SOUTH

Well disinfected upon completion? ☐ Yes ☐ No

14 PUMP:

☐ Not Installed ☐ Pump Installation Only

Manufacturer's name RED JACKET

Model number 2-W HP ½ Volts 230

Length of Drop Pipe 20 5.80 ft. capacity 10 G.P.M.

TYPE: ☑ Submersible ☐ Jet _____

PRESSURE TANK:

Manufacturer's name WELL EXTROL

Model number 202 Capacity _____ Gallons

USE A 2ND SHEET IF NEEDED

15. Remarks, elevation, source of data, etc.

SEP 11 1984

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

PHIL'S WELL DRILLING 0481

REGISTERED BUSINESS NAME REGISTRATION NO.

Address 10785 GRANDVIEW Rd T.C.

Signed PHILIP [illegible] Date 7-19-84

AUTHORIZED REPRESENTATIVE

D67d 2/84

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY NO.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

PART 127 ACT 368, P.A. 1978

PERMIT NUMBER 10152

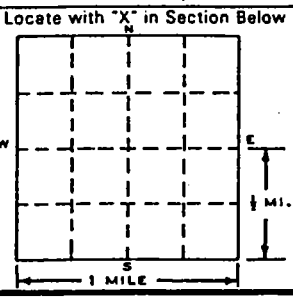
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	SE¼ SE¼ SE¼	8	28 N/S	9 E/W

Distance And Direction From Road Intersection: Angell Rd to Munro Rd - Sec. house North - west side of road.

Street Address & City of Well Location:

Locate with "X" in Section Below



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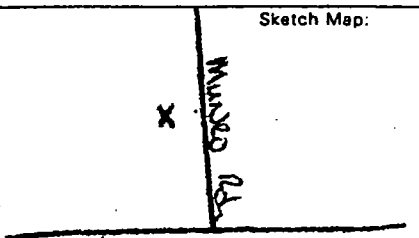


3 OWNER OF WELL:

Bradley Burls

Address: Rt 2 Williamsburg - Mi.

Address Same As Well Location? ☒ Yes ☐ No

4 WELL DEPTH: (completed)

45 ft.

Date of Completion: 9-26-83

5

☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Auger ☐ Jetted ☐ _____

6 USE:

☒ Domestic ☐ Type I Public ☐ Type III Public
☐ Irrigation ☐ Type IIa Public ☐ Heat pump
☐ Test Well ☐ Type IIb Public ☐ _____

7 CASING:

Diameter: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded

5 in. to 40 ft. depth

_____ in. to _____ ft. depth

Grouted Drill Hole Diameter

_____ in. to _____ ft. depth

_____ in. to _____ ft. depth

Height: Above/Below

Surface 1 ft.

Weight .3 lbs./ft.

Drive Shoe ☐ Yes ☐ No

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand	0	10
water Sand	10	32
Sandy Clay	32	40
water Sand	40	45

8 SCREEN:

☐ Not Installed

Type Plastic Diameter 4"

Slot/Gauze .12 Length 5'

Set between 40 ft. and 45 ft.

FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check

☐ Blank above screen 2 ft. Other _____

9 STATIC WATER LEVEL:

10 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface

_____ ft. after _____ hrs. pumping at _____ G.P.M.

_____ ft. after _____ hrs. pumping at _____ G.P.M.

11 WELL HEAD COMPLETION:

☒ Pitless adapter ☒ 12" above grade
☐ Basement offset ☐ Approved pit

12 WELL GROUTED?

☐ No ☒ Yes From _____ to _____ ft.

☐ Neat cement ☒ Bentonite ☐ Other Sand

No. of bags of cement _____ Additives _____

13 Nearest source of possible contamination

Type Septic Distance 50 ft. Direction North

Well disinfected upon completion? ☒ Yes ☐ No

14 PUMP:

☐ Not Installed ☐ Pump Installation Only

Manufacturer's name [redacted] Star Rite

Model number 2- HP ½ Volts 230

Length of Drop Pipe 30 580 ft. capacity 10 G.P.M.

TYPE: ☒ Submersible ☐ Jet _____

PRESSURE TANK:

Manufacturer's name well Mate

Model number 202 Capacity _____ Gallons

USE A 2ND SHEET IF NEEDED

15. Remarks, elevation, source of data, etc.

RECEIVED

JAN 04 1984

16. WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

[redacted] Well Drilling 0481

REGISTERED BUSINESS NAME REGISTRATION NO.

Address 10285 Grandview Rd T.C.

Signed [redacted] Date 10-5-83

AUTHORIZED REPRESENTATIVE

D67d (Rev. 10-80)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No. _____

WATER WELL RECORD

ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

161

1 LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Grand Traverse	Whitewater	SE ¼ NE ¼ NW ¼	16	28 N/S.	9 E/W.

Distance And Direction from Road Intersections: ¼ mile south of Angell Rd. and 600 ft west of the gravel road which runs north and south

OWNER No. _____

Street address & City of Well Location

3 OWNER OF WELL:

McCarty

Address: Elk Rapids

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Top soil	2	2
Clay	108	110
Water sand	5	115

4 WELL DEPTH: (completed)

115 ft. Date of Completion: Dec. 7, 1968

5

☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Jetted ☐ Bored ☐ ___

6 USE:

☒ Domestic ☐ Public Supply ☐ Industry
☐ Irrigation ☐ Air Conditioning ☐ Commercial
☐ Test Well ☐ _____

7 CASING:

Diam. 4 in. to 110 ft. Depth; Threaded ☒ Welded ☐

___ in. to ___ ft. Depth

Height: Above/Below surface 5 ft.

Weight 11 lbs/ft.

Drive Shoe? Yes ☒ No ☐

8 SCREEN:

Type: Stainless steel / Dia.: 4"

Slot/Gauze 10 slot Length 5'

Set between 110 ft. and 115 ft.

Fittings: Lead packer

9 STATIC WATER LEVEL

30 ft. below land surface

10 PUMPING LEVEL below land surface

????? ft. after ___ hrs. pumping ___ g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ????? Chlorides (Cl) _____

Hardness _____

12 WELL HEAD COMPLETION:

☐ In Approved Pit
☒ Pitless Adapter ☐ 12" Above Grade

13 GROUTING:

Well Grouted? ☐ Yes ☒ No

Material: ☐ Neat Cement ☐ _____

Depth: From ___ ft. to ___ ft.

14 SANITARY:

Nearest Source of possible contamination: UNKNOWN

___ feet ___ Direction ___ Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

Manufacturer's Name: Myers

Model Number SE10A-21 HP 1

Length of Drop Pipe 110 ft. capacity 20 G.P.M.

Type: ☒ Submersible ☐ _____
☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Wilbur A. Berg & Sons — REGISTERED BUSINESS NAME

0270 — REGISTRATION NO.

Address: R.R. # 1 Bellaire, Michigan 49615

Signed: Dan W. Berg — AUTHORIZED REPRESENTATIVE

Date: 2-12-69

D67D 100M 6-66

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No. [ ]

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

16B

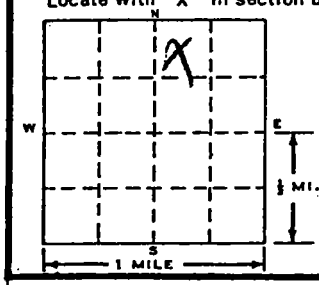
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Grand Traverse	Whitewater	SW¼ NW¼ NE¼	16	28 N/S.	9 E/W.

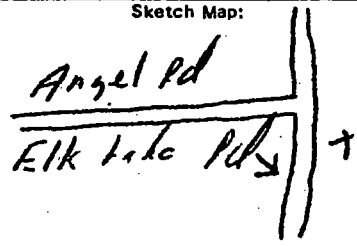
Distance And Direction from Road Intersections: ½ mile south of Angel Rd on Elk Lake Rd

Street address & City of Well Location

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL: Joe Anderson

Address: Williamsburg, Mich

4 WELL DEPTH: (completed) 121 ft. Date of Completion 11-28-75

5 ☐ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☒ Bored ☐ ____

6 USE: ☒ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ____

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 116 ft. Depth; ____ in. to ____ ft. Depth. Height: Above/Below Surface 1 ft. Weight 11.00 lbs./ft. Drive Shoe? Yes ☐ No ☒

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND	70	70
Gravel	24	94
WATER SAND	27	121

8 SCREEN: Type: S.S. Dia.: 4" Slot/Gauze .010 Length 5 Set between 116 ft. and 121 ft. Fittings:

9 STATIC WATER LEVEL: 94 ft. below land surface

10 PUMPING LEVEL below land surface: ____ ft. after ____ hrs. pumping ____ g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☒ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☒ SAND Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination: 50 feet ____ Direction Septic Type. Well disinfected upon completion ☐ Yes ☐ No

15 PUMP: ☐ Not installed. Manufacturer's Name Red Jacket. Model Number 2W HP ½ Volts 230. Length of Drop Pipe 111 ft. capacity 10 G.P.M. Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

17 WATER WELL CONTRACTOR'S CERTIFICATION: This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Phil's Well Drilling Co. (REGISTERED BUSINESS NAME) ____ (REGISTRATION NO.)

Address 10705 Kingsley Rd TC.

Signed [signature] (AUTHORIZED REPRESENTATIVE) Date 12-3-75

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

GEOLOGICAL SURVEY NO. 16-001

PERMIT NUMBER 1 8948

28-13-116-008-10

161

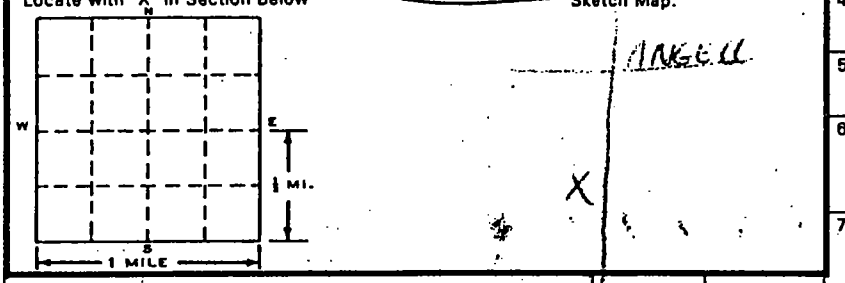
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
GRAND TRAVERSE	WHITEWATER	NE¼ SE¼ NW¼	16	28 N/S	9 E/W

Distance And Direction From Road Intersection: APPROX ¼ OF A MILE SOUTH OF ANGELL

Street Address & City of Well Location: 9643 E ZZ LK RD

Locate with "X" in Section Below / Sketch Map:



3 OWNER OF WELL

JOE ANDERSON

Address: 4606 E ZZ LAKE RD

Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH

137 FT.

Date Completed: MO. 6 DAY 1 YEAR 90

☒ New Well ☐ Replacement Well

5

☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug

☐ Hollow rod ☐ Auger ☐ Jetted ☐

6 USE

☒ Domestic ☐ Type I Public ☐ Type III Public

☐ Irrigation ☐ Type IIa Public ☐ Heat pump

☐ Test Well ☐ Type IIb Public ☐

7 CASING

Diameter: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded

5 in. to 132 ft. depth

in. to ft. depth

Grouted Drill Hole Diameter: 7 7/8 in. to ft. depth

in. to ft. depth

Height: Above/Below Surface 2 ft.

Weight lbs./ft.

Drive Shoe ☐ Yes ☐ No

2 FORMATION DESCRIPTION

	FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
10	topsoil	0	1
20	sand	1	25
21	fine sand	25	63
32	gravel sand	63	120
9	sand-clay-gravel	120	128
20	sand	128	137

8 SCREEN

☐ Not Installed

Type Johnson Diameter 3 pipe

Slot/Gauze .30 Length 5'

Set between 132 ft. and 137 ft.

FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check

☐ Blank above screen 3' ft. Other

9 STATIC WATER LEVEL

110 ft. below land surface 218 M ☐ Flow

10 PUMPING LEVEL: below land surface

125 ft. after hrs. pumping at 9 G.P.M.

ft. after hrs. pumping at G.P.M.

11 WELL HEAD COMPLETION

☒ Pitless adapter ☐ 12" above grade

☐ Basement offset ☐ Approved pit

12 WELL GROUTED?

☐ No ☒ Yes From 4' to 29 ft.

☐ Neat cement ☐ Bentonite ☐ Other

No. of bags of cement Additives vol plug

13 Nearest source of possible contamination

Type septic Distance 50+ ft. Direction N

Well disinfected upon completion? ☒ Yes ☐ No

Was old well plugged? ☐ Yes ☐ No

14 PUMP

☐ Not Installed ☐ Pump Installation Only

Manufacturer's name Duro

Model number 9DA5T HP 3/4 Volts 230

Length of Drop Pipe 125 ft. capacity 9 G.P.M.

TYPE: ☒ Submersible ☐ Jet

PRESSURE TANK

Manufacturer's name None Installed

Model number Capacity Gallons

RECEIVED

JUN 21 1990

GRAND TRAVERSE COUNTY HEALTH DEPARTMENT

USE A 2ND SHEET IF NEEDED

15. Remarks, elevation, source of data, etc.

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Kropp Well Drilling — REGISTERED BUSINESS NAME — 0795 — REGISTRATION NO.

Address 6010 M-72 West T.C.

Signed [signature] — AUTHORIZED REPRESENTATIVE — Date 6/11/90

17. Rig Operator's Name:

Dale Kropp

D67d 2/89

Authority: Act 368 PA 1978

Completion: Required

Penalty: Conviction of a violation of any provision is a misdemeanor.

LOCAL HEALTH DEPT. COPY

16D

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION
WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978
Failure to comply is a misdemeanor

TAX NO: 28-13-116-[illegible]

PERMIT NO: 26680

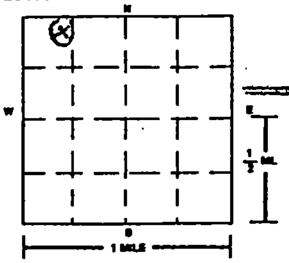
1. LOCATION OF WELL

County	Township Name	Fraction	Section No.	Town No.	Range No.
GRAND TRAVERSE	WHITEWATER	NE 1/4 NW 1/4 NW	16	28N	9W

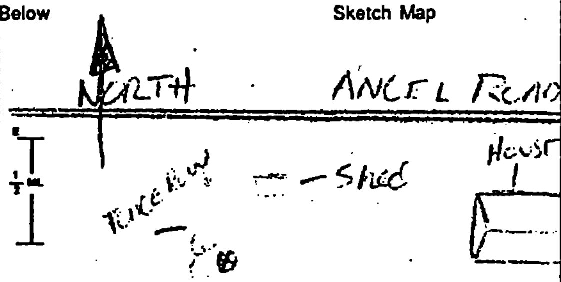
Distance and Direction from Road Intersection
~ 100' SOUTH OF ANGEL ROAD
~ 1400' WEST OF ELK LK. ROAD

Street Address & City of Well Location: 8188 ANGEL ROAD

Locate with 'x' in Section Below



Sketch Map



3. OWNER OF WELL
Address: WILLIAM NAGY
8188 ANGEL ROAD
WILLIAMSBURG, MI
Address Same as Well Location ☒ Yes ☐ No

4. WELL DEPTH: 103 ft. Date Completed: 5/14/99 ☒ New Well ☐ Replacement Well

5. ☐ Cable Tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Auger/Bored ☐ Jetted ☐

6. USE: ☐ Household ☐ Type I Public ☐ Type III Public ☒ Irrigation ☐ Type IIa Public ☐ Heat Pump ☐ Test Well ☐ Type IIb Public ☐

7. CASING: ☐ Steel ☐ Threaded ☒ Plastic ☐ Welded ☐ Other
Height: Above/Below Surface: 1 ft
Diameter: ____ in. to ____ ft. depth
5 in. to 83 ft. depth
Weight: [illegible] lbs./ft.
BORE HOLE: ☐ Drive Shoe ☐ Shale Packer
Diameter: ____ in. to ____ ft. depth
8 1/2 in. to 103 ft. depth

2. FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
sand	5	5
clay	1	06
sand clay gravel	50	56
sand		103

USE A 2ND SHEET IF NEEDED

8. SCREEN: ☐ Not Installed ☒ Gravel-Packed
Type [illegible] Diameter 4"
Slot/Gauze 10 Length: 20'
Set Between 83 ft. and 103 ft.
FITTINGS: ☐ K-Packer ☐ Bremer Check
☒ Blank Above Screen [illegible] ft. Other

9. STATIC WATER LEVEL: 56 ft. Below Land Surface ☐ Flowing

10. PUMPING LEVEL: Below Land Surface
[illegible] ft. After 1 hrs. Pumping at ____ G.P.M.
☐ Plunger ☐ Bailer ☒ Air ☐ Test Pump

11. WELL HEAD COMPLETION:
☐ Pitless Adapter ☒ 12" Above Grade
☐ Basement Offset ☐ Well House

12. WELL GROUTED? ☐ No ☒ Yes From 0 to 73 ft.
☐ Neat Cement ☐ Bentonite ☒ Other: [illegible]
No. of Bags 6 1/2 Additives

13. NEAREST SOURCE OF POSSIBLE CONTAMINATION:
Type [illegible] Distance 100 ft. Direction
Type ____ Distance ____ ft. Direction

14. PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's Name [illegible]
Model Number [illegible] HP 3 Volts 230
Length of Drop Pipe 90 ft. Capacity 50 G.P.M.
TYPE: ☒ Submersible ☐ Jet ☐ Other
PRESSURE TANK: [illegible]
Manufacturer's Name
Model Number [illegible] Capacity ____ Gallons ____

15. ABANDONED WELL PLUGGED? ☐ Yes ☐ No
Casing Diameter ____ in. Depth ____ ft.
PLUGGING MATERIAL: ☐ Neat Cement ☐ Bentonite Slurry
☐ Cement/Bentonite Slurry ☐ Concrete Grout ☐ Bentonite Chips
No. of Bags ____ Casing Removed? ☐ Yes ☐ No

16. REMARKS: (Elevation, Source of Data, etc.)

17. DRILLING MACHINE OPERATOR:
☒ Employee ☐ Subcontractor
Name [illegible]

18. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Phil's Well Drilling Inc. — 0481
REGISTERED BUSINESS NAME — REGISTRATION NO.
Address 3783 [illegible] Rd TC 49684
Signed [signature] AUTHORIZED REPRESENTATIVE Date 5-20-99

RECEIVED JUN 08 1999

EQP 2017 (12/96)

LOCAL HEALTH DEPT. COPY

APPENDIX C

SELECT EXCERPTS-

HYDROLOGY AND LAND USE
IN
GRAND TRAVERSE COUNTY, MICHIGAN

U.S. Geological Survey
Water Resources Investigations Report 90-4122

HYDROLOGY AND LAND USE IN GRAND TRAVERSE COUNTY, MICHIGAN

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 90-4122

Prepared in cooperation with

GRAND TRAVERSE COUNTY and the
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY DIVISION

HYDROLOGY AND LAND USE IN GRAND TRAVERSE COUNTY, MICHIGAN

by

T.R. Cummings, J.L. Gillespie, and N.G. Grannemann

ABSTRACT

Glacial deposits are the sole source of ground-water supplies in Grand Traverse County. These deposits range in thickness from 100 to 900 feet and consist of till, outwash, and materials of lacustrine and eolian origin. In some areas, the deposits fill buried valleys that are 500 feet deep. Sedimentary rocks of Paleozoic age, which underlie the glacial deposits, are mostly shale and are not used for water supply.

Of the glacial deposits, outwash and lacustrine sand are the most productive aquifers. Most domestic wells obtain water from sand and gravel at depths ranging from 50 to 150 feet and yield at least 20 gallons per minute. Irrigation, municipal, and industrial wells capable of yielding 250 gallons per minute or more are generally greater than 150 feet deep. At places in the county where moranial deposits contain large amounts of interbedded silt and clay, wells are generally deeper and yields are much lower.

Areal variations in the chemical and physical characteristics of ground and surface water are related to land use and chemical inputs to the hydrologic system. Information on fertilizer application, septic-tank discharges, animal wastes, and precipitation indicate that 40 percent of nitrogen input is from precipitation, 6 percent from septic tanks, 14 percent from animal wastes, and 40 percent from fertilizers.

Streams and lakes generally have a calcium bicarbonate-type water. The dissolved-solids concentration of streams ranged from 116 to 380 milligrams per liter, and that of lakes, from 47 to 170 milligrams per liter. Water of streams is hard to very hard; water of lakes ranges from soft to hard. The maximum total nitrogen concentration found in streams was 4.4 milligrams per liter. Water of lakes have low nitrogen concentrations; the median nitrate concentration is less than 0.01 milligrams per liter. Pesticides (Parathion and Simazine) were detected in low concentrations at six stream sites; 2,4-D was detected in low concentrations in water of two lakes. Relationships between land use and the yield of dissolved and suspended substances could not be established for most stream basins.

Calcium and bicarbonate are the principal dissolved substances in ground water. Dissolved-solids concentrations ranged from 70 to 700 milligrams per liter; the countywide mean concentration is 230 milligrams per liter. The mean nitrate concentration is 1.3 milligrams per liter; about 1.6 percent of the county's ground water has nitrate concentrations that exceed the U.S. Environmental Protection Agency's maximum drinking water level of 10 milligrams per liter. An effect of fertilizer applications on ground-water quality is evident in some parts of the county.

INTRODUCTION

An increased demand for water by irrigators, municipalities, and industries is affecting development throughout the country. Long-term effects, however, can rarely be predicted without detailed geologic and hydrologic information. Along with climate, geologic conditions control the natural chemical characteristics of water. Concern over the changes in the natural quality of both ground and surface waters has prompted examination of how land use modifies the suitability of water for its varied uses. Such changes are usually subtle, and not easily measured in a short period of time.

This study is one of a series of three county studies that attempt to relate hydrology to land use in Michigan. Other studies have been conducted in Van Buren and Kalamazoo Counties. Grand Traverse County was selected because agricultural development, although intense at places, was not as prevalent countywide as in the areas previously studied, and because general environmental conditions are different in the northern part of Michigan's Lower Peninsula.

The study was done in cooperation with Grand Traverse County and the Geological Survey Division of the Michigan Department of Natural Resources. The compilation of land-use data, information of fertilizer use, animal populations, and septic-tank installations were the responsibility of the Grand Traverse County Extension Service. Collection and analysis of geologic, hydrologic, and water-quality data were the responsibility of the U.S. Geological Survey.

Purpose and Scope

This report describes the results of a study of the chemical and physical characteristics of ground and surface water in Grand Traverse County and to relate these characteristics to land use. The investigation required an assessment of the chemical inputs to the hydrologic system, including those of precipitation, animal wastes, septic tanks, and fertilizers. Data on geology and hydrology, which provide the necessary basis for interpretations, were also collected and evaluated. Readily available land-use data were compiled for use.

General Description of Study Area

Grand Traverse County is in the northwestern part of Michigan's Lower Peninsula (fig. 1). On the north it is bounded by the East and West Arms of Grand Traverse Bay, a part of Lake Michigan. The Boardman River, which drains the central part of the county, flows to the Bay. The land surface is flat to rolling and ranges in elevation from about 580 ft (feet) above sea level at Lake Michigan to about 1,180 ft in the southeastern part of the county (fig. 2). The county has about 240 lakes and ponds.

The county comprises about 485 mi^2 (square miles) and is composed principally of cropland, orchards, and forests. Its population is about 55,000 (U.S. Bureau of Census, 1982). The largest community is Traverse City, which has a population of about 15,000 (fig. 3).

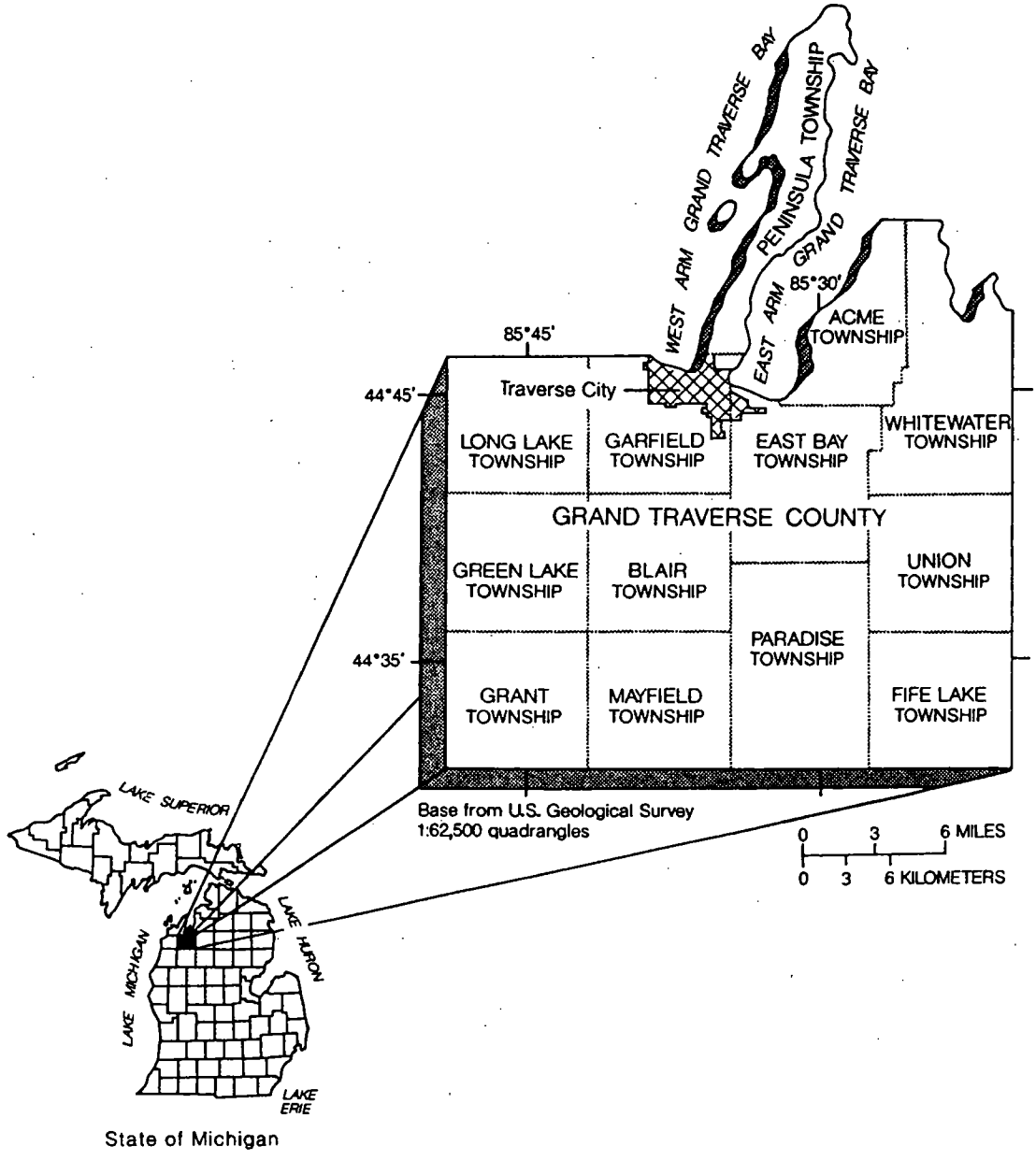


Figure 1.--Location of Grand Traverse County.

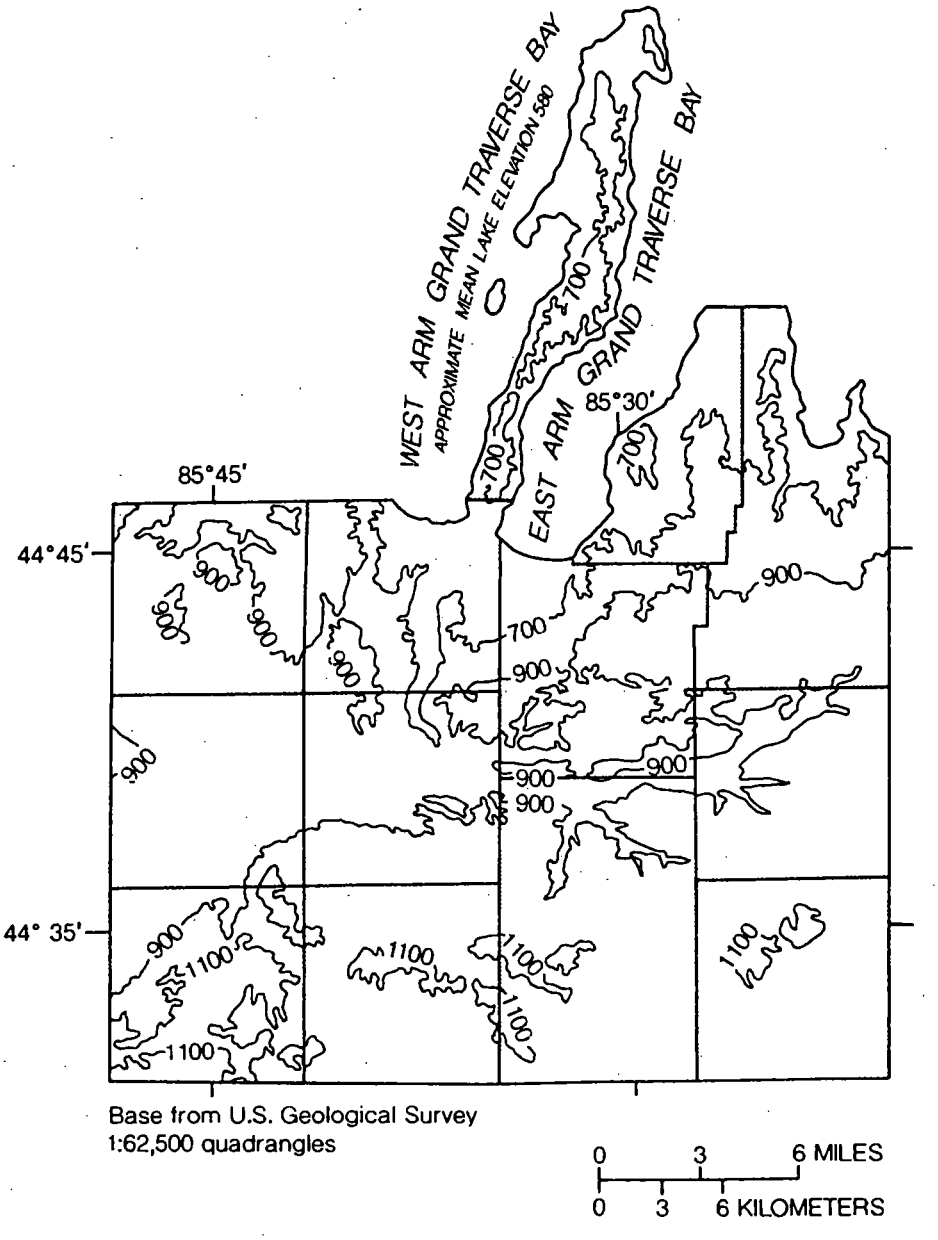


Figure 2.--Elevation of land surface.

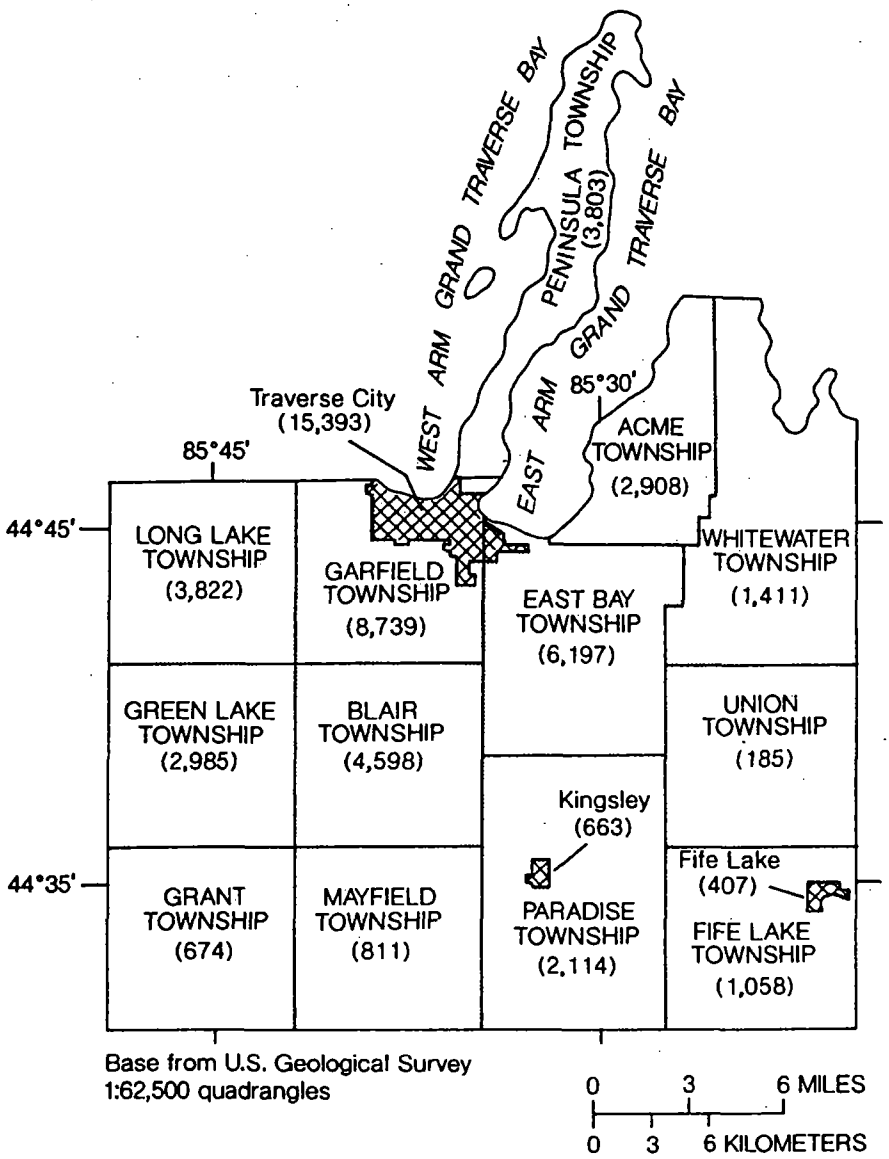


Figure 3.--Population in 1980, by township. (U.S. Bureau of Census, 1982.)

Average annual precipitation for Grand Traverse County is about 31 in. (inches). It ranges from 30 in. at Grand Traverse Bay to 32 in. inland. Average snowfall, measured from July to June, ranges from 87 in. at Traverse City to 106 in. at the Village of Fife Lake in the southeastern part of the County (Fred Nurnberger, Michigan Weather Service, oral commun., 1990). Mean monthly temperatures range from 16 °F (Fahrenheit) to 65 °F.

Farming is an important part of the county's economy. Fruits, vegetables, and field crops can be raised satisfactorily with rainfall; however, irrigation increases yields and provides greater profits. About 2,000 acres are irrigated (R.L. Van Til, Michigan Department of Natural Resources, written commun., 1985). From 1970 to 1977, the amount of water used for irrigation increased 324 percent. Tourism is also important to the economy. In summer, the mild climate, the bay, and the many lakes make the county a popular recreational area. In winter, abundant snow and ice-covered lakes provide excellent conditions for winter sports. Oil and gas exploration and development are expanding in the southeastern part of the county.

Of the 55,000 residents of Grand Traverse County, about 40,000 depend on ground water for domestic supplies. The remaining residents obtain water from the Traverse City municipal systems, which pumps water from the East Arm of Grand Traverse Bay.

GEOLOGY

Grand Traverse County is underlain by sedimentary rocks of Paleozoic age that consist mostly of shale, limestone, and sandstone. Glacial deposits, the result of continental glaciation during the Pleistocene Epoch, consist of gravel, sand, silt, and clay. These unconsolidated deposits completely cover the bedrock surface and are as much as 900 ft thick at places.

Bedrock

Bedrock directly underlying the glacial deposits is divided into six geologic units (fig. 4). These geologic units are, in ascending order, the Antrim, Ellsworth, Sunbury, and Coldwater Shales, and the Marshall and Michigan Formations. The four shale units underlie all of the county except for the southeastern part which is underlain by the Marshall and Michigan Formations. The Marshall Formation is primarily a sandstone; the Michigan Formation is primarily a limestone.

Structurally, bedrock underlying the county is part of the Michigan basin, a bowl-shape feature with a center that roughly coincides with the geographical center of Michigan's Lower Peninsula (fig. 1). Geologic units dip toward the center of the basin where the youngest rocks subcrop. Therefore, the bedrock units in Grand Traverse County dip southeastward.

Elevation of the bedrock surface ranges from about 200 ft below sea level in the western part of the county to about 700 ft above sea level in the southeastern part of the county. Weathering and erosion throughout geologic time have created this variable relief. During periods of glaciation, erosion deepened pre-existing bedrock valleys and filled them with unconsolidated

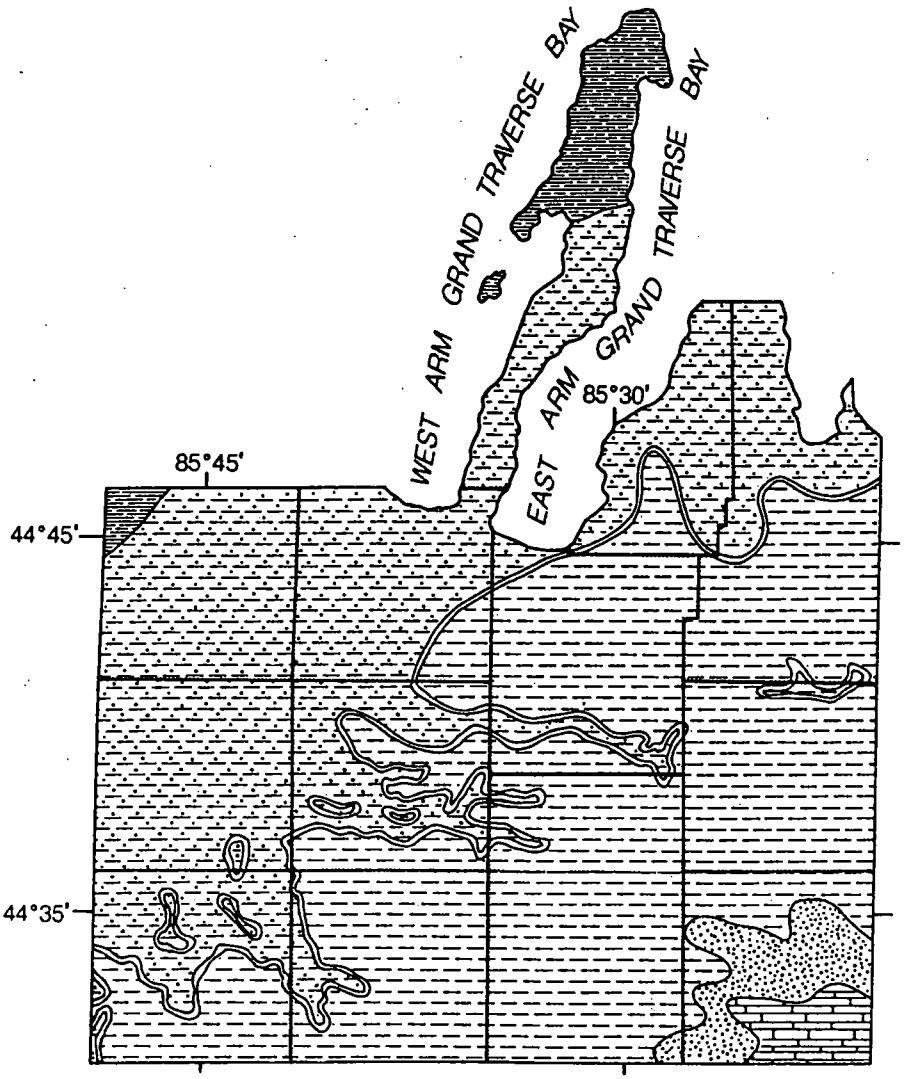


Figure 4.--Areal distribution of bedrock.

glacial deposits. One major buried valley, 500 ft below the elevation of the surrounding bedrock surface, trends north-south in the southwestern part of the county; two other major buried valleys trend east-west (fig. 5).

Scant data are available to determine the elevation of bedrock in the northwestern part of the county and on Old Mission Peninsula (pl. 1). At present, there are no wells that penetrate bedrock in these areas. Analysis of data from the few wells that do exist indicate that bedrock is at least 300 ft below land surface.

Glacial Deposits

Continental glaciation ended about 10,000 years ago in the northwestern Lower Peninsula of Michigan. As the glaciers melted, they left behind extensive deposits of gravel, sand, silt, and clay. The thickness of these deposits ranges from about 100 to about 900 ft. The lithology of the upper part of these deposits is indicated by the logs of 36 wells (table 1, at back of report) installed by the U.S. Geological Survey. At some locations the glacial deposits have been reworked, eroded by wind and streams, or eroded by wave action in the ancestral Great Lakes, whose water levels fluctuated as much as 200 ft after deglaciation (Hough, 1958).

Glacial deposits found in Grand Traverse County include till, glaciofluvial, and lacustrine deposits. Alluvial deposits of more recent origin occur near stream channels; eolian deposits occur near shorelines. The different types of glacial deposits are associated with landforms, such as till plains, outwash plains, moraines, and lake plains. The composition of these deposits, however, ranges from coarse gravel to clay.

Till is a mixture of gravel, sand, silt, and clay. In Grand Traverse County, till can be either coarse or fine grained. At some locations, boulders and cobbles also are present. Surficially, moraines in the county are composed of till that is primarily sand, gravel, and silt; moraines contain a relatively small amout of clay (Farrand, 1982). The moraines, which trend east-west, were formed when sediments were deposited as the glacier retreated. The Manistee moraine crosses the northern part of the county; the Port Huron moraine crosses the southern part (fig. 6).

Relief in areas of moraines is variable and is referred to as hummocky topography. Hummocky topography developed when differential melting of the glacier caused sediment to accumulate in low areas on the ice surface, which prevented the ice from melting rapidly. Depressions or kettle lakes on the land surface are places where ice blocks covered by sediment melted.

Till plains are present on Old Mission Peninsula and in the extreme northeastern part of the county. Topography at these locations consists of rolling plains and drumlins. Drumlins are smooth, glacially formed hills, elongated and aligned parallel to the direction of glacier movement. Drumlins are commonly found in fields; similar forms are found grouped together. The drumlins were probably caused by a readvance of glacial ice for a relatively short period of time.

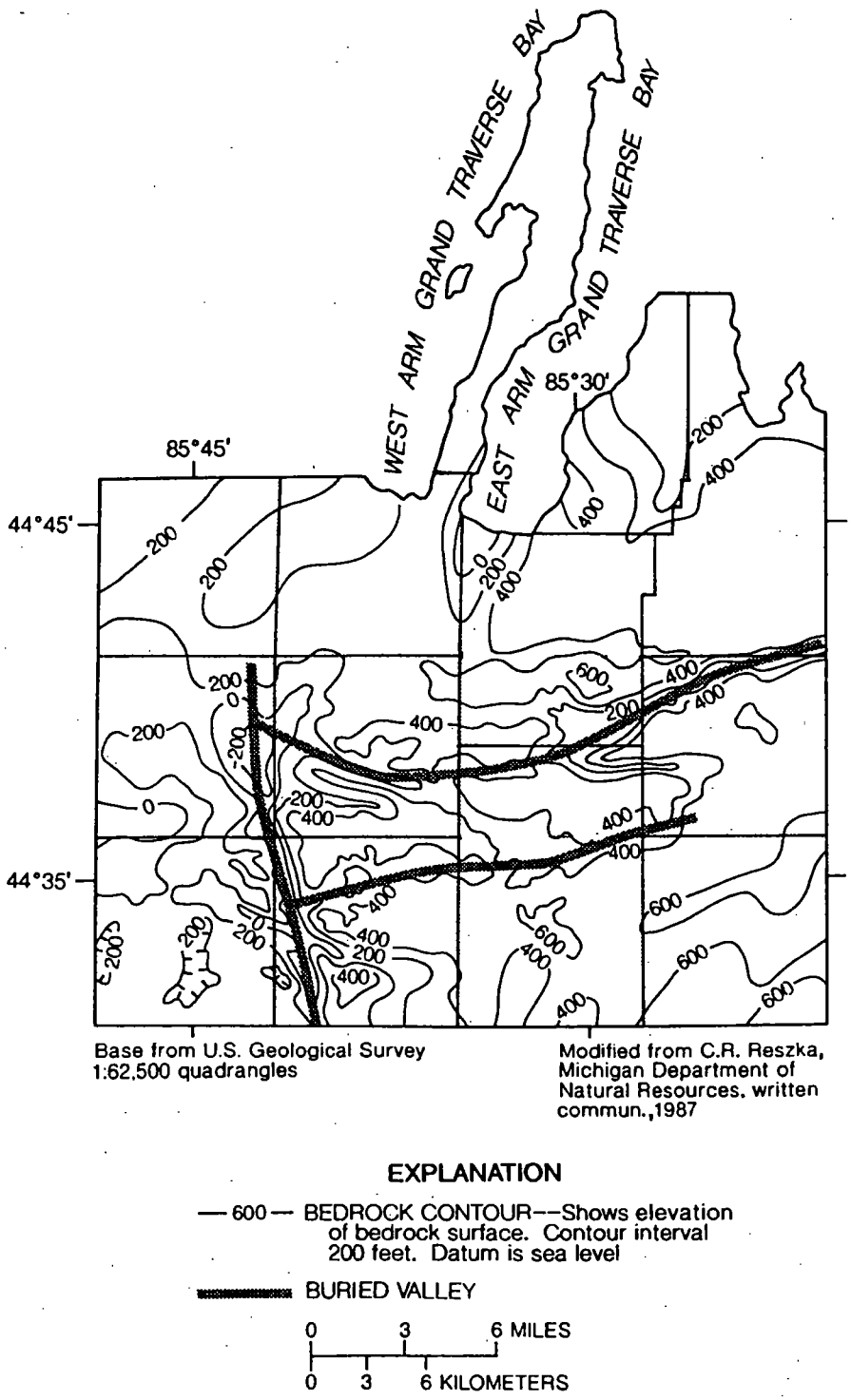


Figure 5.--Buried valleys and configuration of the bedrock surface.

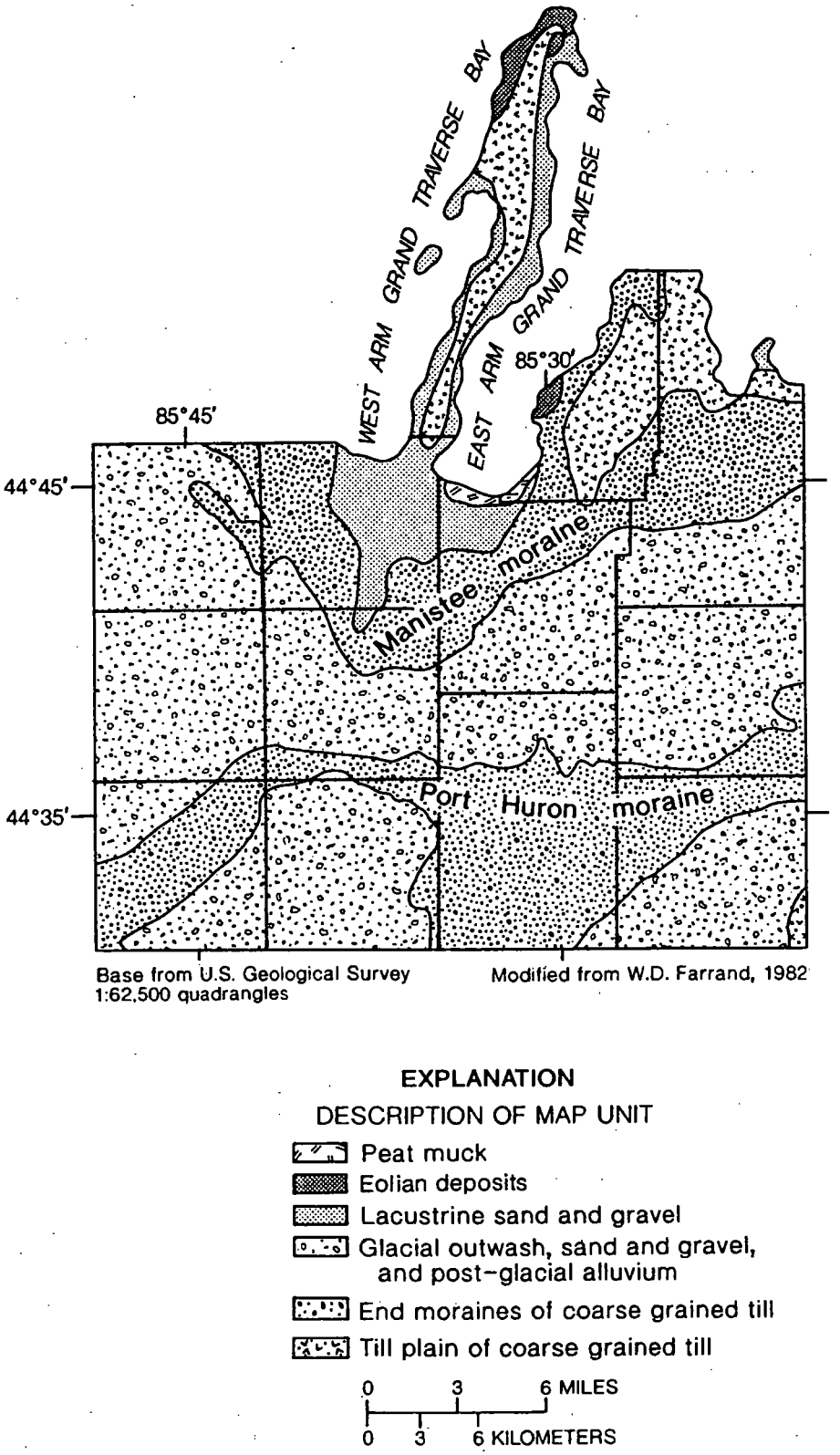


Figure 6.--Areal distribution of glacial deposits.

Outwash plains, which are stratified sand and gravel deposits, are formed by glacial meltwater as multiple braided stream systems coalesce at or near ice margins. An extensive outwash plain trends east-west across the middle of the county between the Manistee and Port Huron moraines. It was created by sediment-laden meltwater that flowed from glacial ice when the Manistee moraine was formed (fig. 6). Outwash in the southeastern and southwestern parts of the county is similarly associated with the Port Huron moraine. Drainage of the outwash plains was to the west-southwest.

Relief of the outwash plains changes from level to gently steepening in the direction of ancestral drainage. The area of greatest relief on the outwash plains occurs where the Boardman River has downcut into the plain to flow to Lake Michigan. Relief in this area is as great as 150 ft.

Lacustrine deposits range from sand to clay, depending on the depositional environment. High-energy environments, such as beaches, are composed mostly of sand; low-energy environments, such as distal parts of lakes, are predominantly clay. In Grand Traverse County, lacustrine deposits such as beach sands, deltaic sands, and lakebed clays, are found at the surface and in the subsurface. Beach sands are found along Old Mission Peninsula. From Traverse City east to Acme, the area is a sandy lake plain. Deltaic sand deposits are found where the ancestral Boardman River downcut through the Manistee moraine and flowed into ancestral Grand Traverse Bay. The relief of lacustrine deposits is usually flat except where old beach ridges are found.

Eolian deposits are found at the tip of Old Mission Peninsula and consist mostly of well-sorted sand. These deposits are topographic highs, and are dune shaped. They were formed by northeasterly winds from Lake Michigan. Other eolian deposits are found on the eastern shore of the East Arm of Grand Traverse Bay. Alluvial deposits are found mostly along the Boardman River, whose flood plain is as much as 4,000 ft wide.

HYDROLOGY

In Grand Traverse County, about 16 in. of the annual average precipitation (31 in.) are evaporated or transpired by plants. Of the remaining 15 in., about 4 in. become streamflow; about 11 in. percolate to the water table and recharge ground-water reservoirs.

Surface Water

Grand Traverse County is drained largely by the Boardman River in the northern and central part, by the Betsie River and its tributaries in the western part, and by tributaries of the Manistee River in the southern part. The county has about 240 lakes and ponds which comprise about 28 mi^2 or 6 percent of the county (Humphrys and Green, 1962).

Streams

A daily discharge record on the Boardman River near Mayfield (U.S. Geological Survey surface-water station 04127000) has been obtained since 1952. Average discharge for the period of record is 196 ft^3/s (cubic feet per

second). The maximum discharge, 1,220 ft^3/s, occurred in September 1961; the minimum, 30 ft^3/s, occurred in January 1965. Figure 7 shows hydrographs for this station from October 1983 through September 1986.

During this investigation, measurements of discharge were made periodically at 24 sites at the time water-quality samples were collected. The locations of these sites are shown on plate 1; maximum and minimum discharges at each site are given in table 2. Twenty-four drainage areas, lettered A to X, have been defined based on the locations of these sites. Figure 8 shows the boundaries of these areas. Based on the data shown in table 2, runoff at high flow ranged from 0.77 $(ft^3/s)/mi^2$ (cubic feet per second per square mile) at Anderson Creek near Buckley to 5.7 $(ft^3/s)/mi^2$ at Hospital Creek at Traverse City. Runoff at low flow ranged from 0.056 $(ft^3/s)/mi^2$ at Tobeco Creek near Elk Rapids to 1.5 $(ft^3/s)/mi^2$ at Williamsburg Creek near Williamsburg.

Lakes and Ponds

The lakes in Grand Traverse County range from 0.1 to 2,860 acres in size; a depth as great as 102 ft has been measured. Long Lake is the largest in the county; Green Lake is the deepest. The location of principal lakes is shown on plate 1. About 71 percent of the lakes have neither inlet nor outlet, about 20 percent have inlets and outlets, about 8 percent have outlets only, and less than 1 percent have inlets only. With the exception of Peninsula Township, lakes and ponds are well distributed throughout the county.

Ground Water

In Grand Traverse County, most ground water is contained and flows in the glacial deposits that overlie bedrock. It generally flows toward Grand Traverse Bay or to streams that are tributary to the bay, except in the southern part of the county where it flows to the south, southeast, and southwest out of the county. The occurrence and distribution of water in bedrock has not been thoroughly investigated, and little is known of its movement.

Aquifers

The nature and size of pore spaces and other openings in rocks are the primary factors controlling the movement and storage of ground water in aquifers. The major aquifers in the county are the outwash sand and gravel and lacustrine sand deposits. These deposits, which have large interconnected pore spaces, readily transmit water and are the most common sources of water. Till, lacustrine silts and clays, and other fine-grained deposits have relatively low porosity which restricts the flow of water; they yield only small amounts of water to wells.

Within the glacial deposits, layers of till or till and clay are present in much of the county. Figure 9 is a geologic section from Bellen Lake through Long, Bass, and Silver Lakes that shows an increase in fine-grained units from west to east. These units divide the glacial deposits into many water-bearing units. In the lower units, ground water is partly confined by till and clay; in areas where outwash or lacustrine sand deposits are at land surface, however, ground water is unconfined.

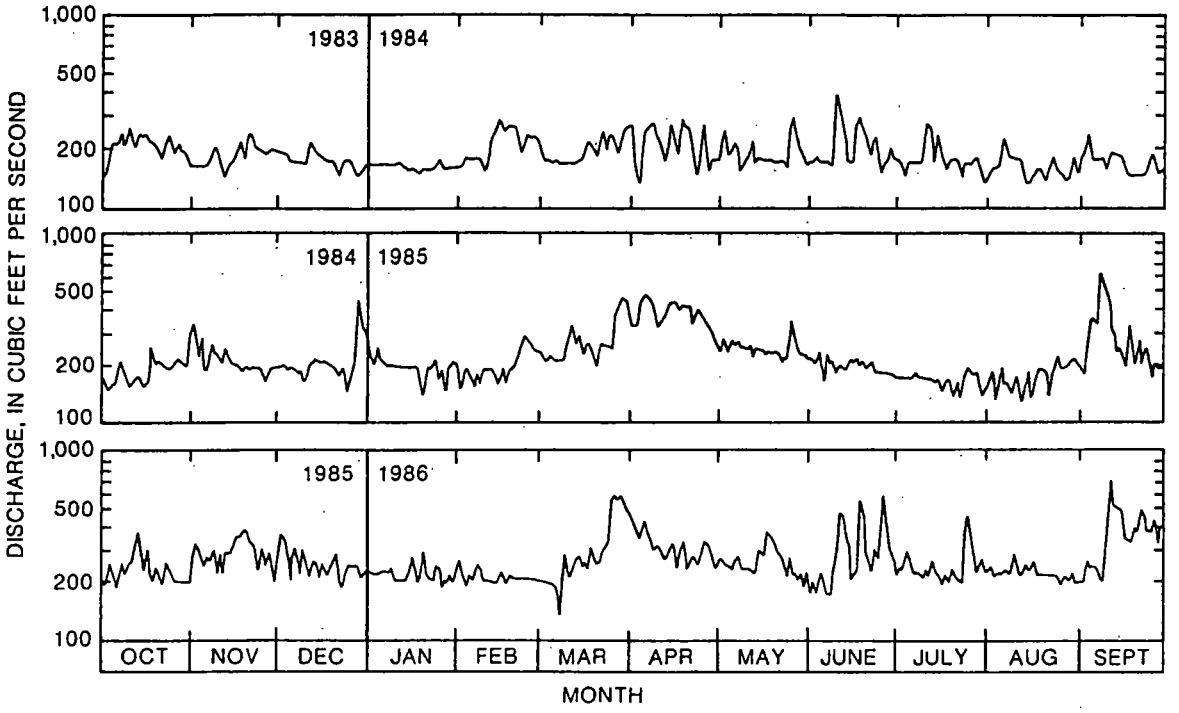


Figure 7.--Discharge of Boardman River near Mayfield, October 1983 through September 1986.

Table 2.--Maximum and minimum discharges at periodically measured sites in Grand Traverse County, 1984-86

[ft^3/s, cubic feet per second]

Site number	Station number and name	Number of measurements	Maximum discharge (ft^3/s)	Minimum discharge (ft^3/s)
1	04123706 Fife Lake Outlet near Fife Lake	7	22	9.2
2	04123910 Anderson Creek near Buckley	22	25	6.4
3	04126525 Mason Creek near Grawn	7	17	7.6
4	04126532 Duck Lake Outlet near Interlochen	7	52	22
5	04126546 Green Lake Inlet near Interlochen	20	132	16
6	04126550 Betsie River near Karlin	7	93	42
7	04126958 North Branch Boardman River near South Boardman	7	91	43
8	04126950 South Branch Boardman River near South Boardman	8	70	38
9	04126970 Boardman River at Brown Bridge Road near Mayfield	23	338	99
10	04126995 Jackson Creek near Kinglsey	6	11	4.5
11	04126997 East Creek near Mayfield	22	115	16
12	04126991 Boardman River below Brown Bridge Pond near Mayfield	21	393	106
13	04127008 Swainston Creek at Mayfield	22	19	11
14	04127019 West Branch Jaxon Creek near Mayfield	7	1.2	.11
15	04127250 Boardman River near Traverse City	22	539	217
16	04127490 Boardman River at Traverse City	22	577	192
17	04127498 Hospital Creek at Traverse City	22	44	8.5
18	04127520 Mitchell Creek at Traverse City	23	28	4.7
19	04127528 Acme Creek at Acme	22	22	13
20	04127535 Yuba Creek near Acme	22	22	5.0
21	04127550 Tobeco Creek near Elk Rapids	22	19	.61
22	04127600 Battle Creek near Williamsburg	22	19	9.4
23	04127620 Williamsburg Creek near Williamsburg	22	28	12
24	04126845 Cedar Run near Cedar	3	10	8.3

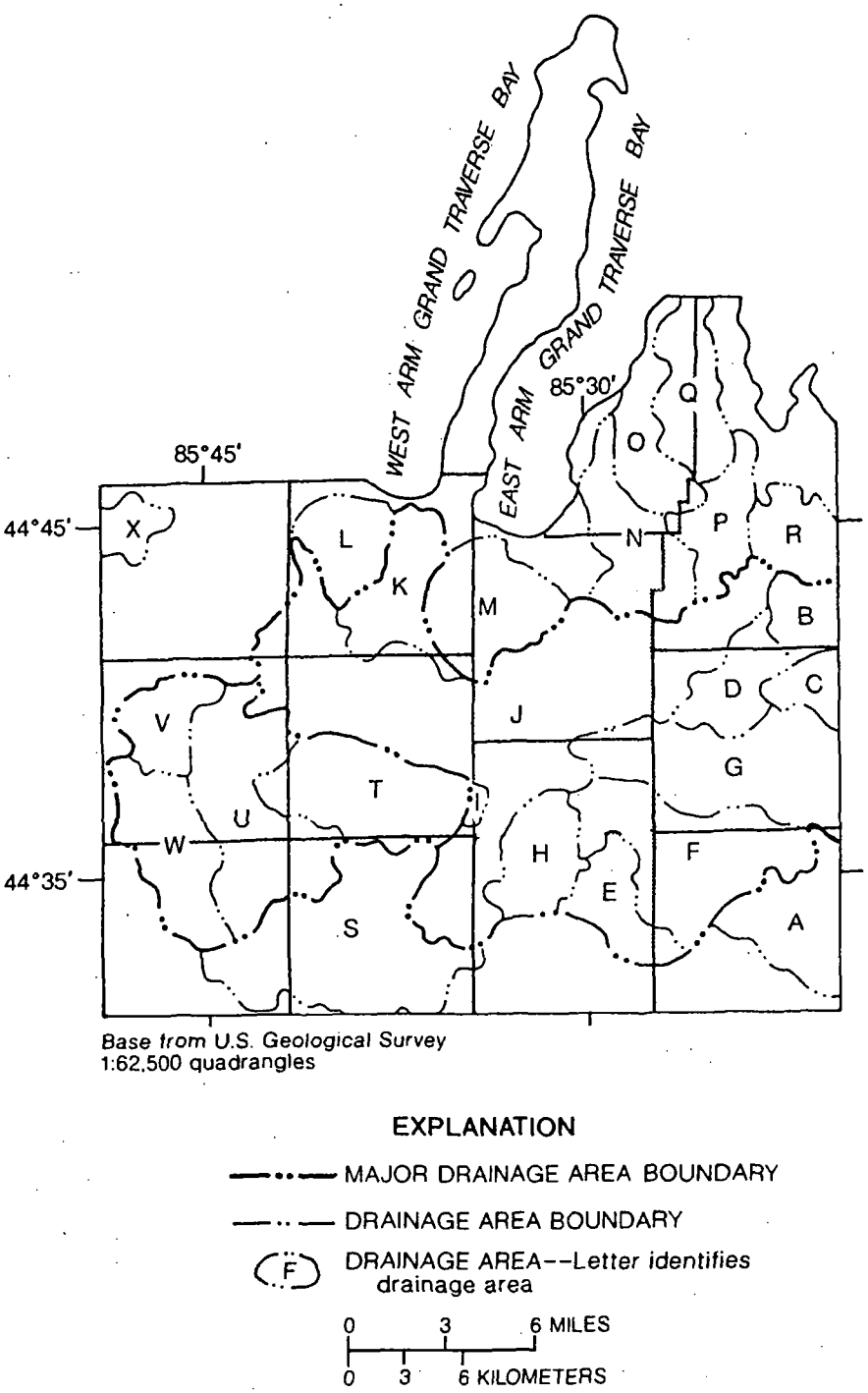


Figure 8.--Drainage areas.

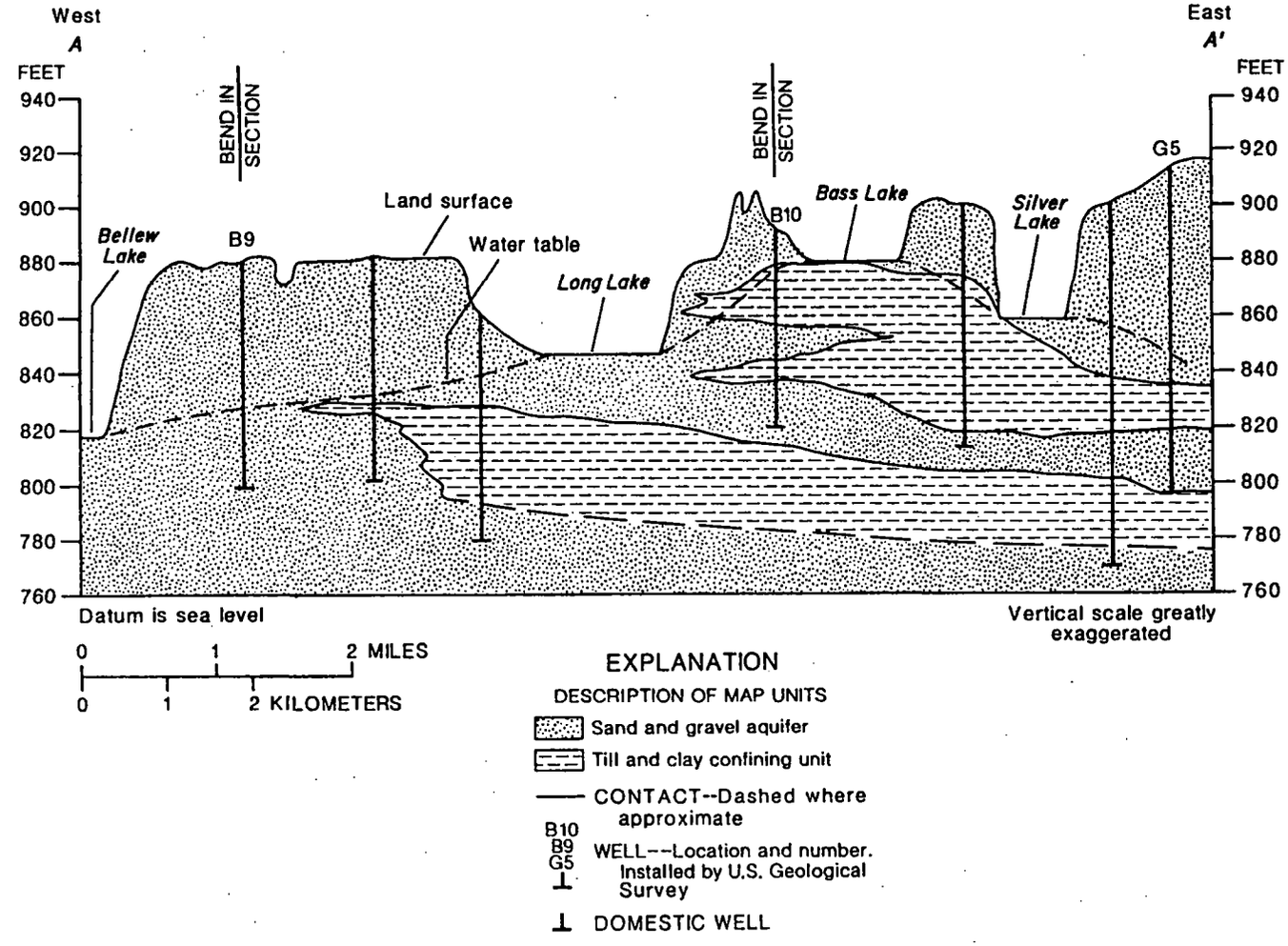


Figure 9.--Relation of till and clay confining units to sand and gravel aquifers near Long, Bass, and Silver Lakes. (Line of section shown on plate 1.)

The Marshall Formation, a sandstone, underlies about 14 mi^2 of the southeastern part of Grand Traverse County. It is a well known and productive aquifer in other parts of Michigan. Few wells have penetrated the formation in the county, however, and little is known about its hydraulic properties. Other bedrock in the county is not likely to yield significant water at most places.

Water Table and Ground-Water Flow

The elevation of the water table, directions of horizontal ground-water flow, and ground-water divides are shown on plate 2. The map was prepared by determining depth-to-water from well-drillers' records and subtracting the depth from the land-surface elevation shown on U.S. Geological Survey topographic quadrangles. These values were hand contoured to show lines of equal elevation. Where well-record coverage in the county was sparse, the elevation of streams and lakes were used to estimate the elevation of the water table.

The configuration of the water table is similar to the land-surface topography, except that the variation of the elevation of the water table is subdued. For example, the water table is about 40 ft higher on Old Mission Peninsula than it is at Grand Traverse Bay; variation in land surface elevation is as much as 200 ft between the two areas. Most ground water in the county flows toward the bay.

A major influence on the configuration of the water table and direction of ground-water flow is the Boardman River. Ground water flowing northward discharges to the river, which has cut a deep valley in the glacial deposits. Ground water on either side of the valley flows to the river, which eventually discharges to Grand Traverse Bay. Some ground water beneath confining units probably flows under the river.

In the northwestern part of the county near Bass Lake, a major ground-water divide extends north to south for about 10 mi, and then eastward to the southeastern edge of the county near Fife Lake. North and east of the divide, ground water discharges toward the Boardman River or Grand Traverse Bay. South and west of the divide, ground water flows toward adjacent counties.

The water table fluctuates throughout the year. Water levels usually rise during the winter and spring when evapotranspiration is low; they decline during summer when evapotranspiration is high. Ground-water levels in 20 observation wells were measured during 1985-86 (table 3, at back of report). Measurements of water levels in an observation well near Fife Lake from 1976-88 indicate that the water table responds to changes in rainfall and/or snowmelt (fig. 10). Seasonal and long-term responses to recharge are evident. For example, a rise of 1 to 2 ft in the water level occurs each spring. Long-term responses are less dramatic and are related to annual precipitation. Figure 10 shows precipitation for and the departure from normal precipitation at Traverse City Airport during 1976-88. During a period of reduced precipitation, such as during 1980-82, water levels were low. When precipitation was normal or above, as during 1983-86, water levels increased. Snowmelt usually occurs in late March. At about this time, ground-water levels begin to rise for 2 or 3 months, depending on the amount and time of

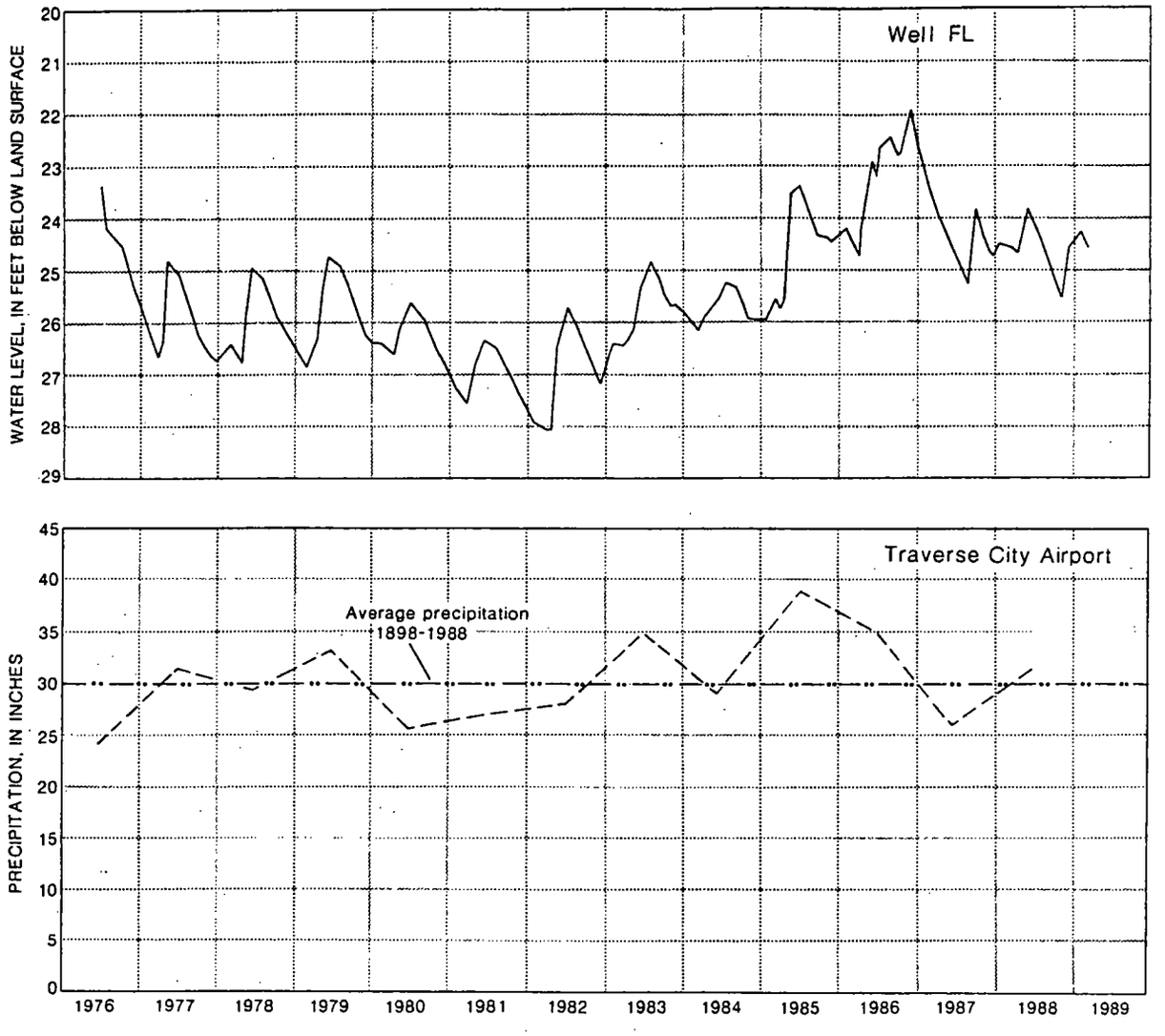


Figure 10.--Water-level fluctuations in observation well FL near Fife Lake, 1976-88, and annual precipitation at the Traverse City Airport, 1976-88.

rainfall. Seasonal water-level peaks usually occur between late May and early July. Occasionally, a second peak occurs in late autumn when rainfall increases and evapotranspiration decreases.

Depth and Yield of Water-Bearing Deposits

Plate 3 is a map showing generalized depth to water-bearing deposits in Grand Traverse County. The map indicates the depth to which a well must be drilled within the glacial deposits to obtain a domestic water supply of 10 gal/min (gallons per minute). If the hydraulic properties of the glacial deposits near the water table are unsatisfactory, depth of drilling may need to be increased to find a water-bearing zone. These zones are usually coarse-grained sand and gravel deposits.

In general, outwash and lacustrine deposits are coarse-grained. Wells installed in these deposits are usually shallow because the water table is close to the land surface. Where outwash or lacustrine deposits are present, most wells are less than 100 ft deep. Confining units are usually not present in these areas at shallow depths.

Fine-grained materials, associated with till and distal lacustrine deposits, are found in parts of the county where moraines are present. Wells in these areas range from 100 to 300 ft deep and generally have low yields. At least one confining unit usually is present, but the deepest wells will penetrate through multiple confining units to reach a productive zone.

Depth to water is related to type of glacial deposit in the county. The highest land-surface elevations and greatest topographic relief are associated with morainal deposits; the depth to water in these areas is greater than in areas of outwash deposits. Even though some of the deposits are coarse grained and could yield water to wells, they are above the water table. Outwash and lacustrine deposits are associated with low topographic relief and low land-surface elevations. Depth to water is less in these areas than in moranial areas. In a few areas where the water table is only a few feet below land surface, coarse-grained deposits sufficient to store water are not present.

Domestic wells in most of the county obtain sufficient supplies from wells 50 to 150 ft deep. These wells usually have a 4-in.-inside diameter casing, a screened interval of 4 ft, and yield at least 20 gal/min. Irrigation, municipal, and industrial wells are usually 150 to 450 ft deep and are capable of yielding 250 gal/min or more. These wells have at least a 6-in.-inside diameter casing and have a much greater screened interval in the water-bearing zone than do domestic wells.

Hydraulic Properties of Aquifers

The only bedrock units in the county that may have potential for providing usable supplies of water are the sandstones of the Marshall Formation. Because of the depth at which the Marshall Formation lies and because the formation is not tapped for water supplies, no hydrogeologic data regarding the formation were collected during this study. Other bedrock units

that underlie the glacial deposits are thought to be as poor aquifers in Grand Traverse County as they are in other parts of the State because they consist principally of shales.

The hydraulic properties of the glacial deposits depend on the type of deposit. Aquifer tests were conducted at two locations during this study to determine the horizontal hydraulic conductivity and specific yield of glaciofluvial deposits. The tests were conducted north of Fife Lake (well FL) and south of Karlin (well GP1) (plate 1). The transmissivity of deposits at well FL was 4,300 ft^2/d (feet squared per day); the specific yield was 0.30. The transmissivity of deposits at well GP1 was 2,500 ft^2/d; the specific yield was 0.25. Hydraulic conductivities were 80 and 50 ft/d (feet per day) for wells FL and GP1, respectively. Aquifer-test data from previous investigations are available at the Village of Kingsley and at the U.S. Coast Guard Air Station, Traverse City. Analysis of the aquifer test conducted at the Village of Kingsley for a public-supply well indicates transmissivity ranges from about 3,000 to 3,800 ft^2/d for the leaky confined sand and gravel aquifer. Hydraulic conductivities determined for the aquifer range from 55 to 70 ft/d. Analysis of the aquifer test made at the U.S. Coast Guard Air Station indicates that transmissivity ranges from 1,800 to 2,600 ft^2/d for the unconfined sand and gravel aquifer. Horizontal hydraulic conductivity calculated from the transmissivity ranges from 100 to 150 ft/d. No aquifer tests have been conducted in fine-grained deposits such as till or lacustrine clay.

The velocity of horizontal ground-water flow depends on the hydraulic gradient, the hydraulic conductivity, and the effective porosity of the aquifer. Near well FL, the velocity of ground water is about 1 ft/d. At the U.S. Coast Guard Air Station, velocities ranged from 3 to 6 ft/d because of comparatively steep gradients, high hydraulic conductivities, and low effective porosities.

WATER QUALITY AND LAND USE

In Grand Traverse County, as in other parts of Michigan and the country, the relation of land use to the chemical and physical characteristics of water is not always evident. To investigate possible relations in Grand Traverse County, current information on the chemical inputs to the hydrologic system, particularly the nitrogen input, was considered essential. Data on fertilizer applications, animal wastes, septic-tank discharges, and chemical composition of precipitation were compiled as the first step in evaluating water quality.

Inventory of Land Use

The Michigan Department of Natural Resources' Division of Land Resource Programs is responsible for implementing the Michigan Resource Inventory Act of 1979. One requirement of the act is that a current-use inventory of each county be maintained. Land use or land cover is classified using 46 catagories, which are designed to identify existing use of every 2.5- to 5.0-acre area of land in the State. Land use or cover exceeding 4 percent of the total area of Grand Traverse County include: northern hardwood forest land, 24.73 percent; cropland, 16.14 percent; mixed pine forest land, 14.63 percent; herbaceous openland, 10.68 percent; orchards, 5.19 percent; single-family duplex, 4.56 percent; and lowland hardwoods, 4.15 percent (Michigan Department

of Natural Resources, written commun., March 27, 1985). Table 4 lists land-use data for Grand Traverse County by township. Although data tabulated in table 4 are accurate indications of land classification, the actual area in a township devoted to a given use may be substantially less than that falling within a classification. In order to relate water quality to agricultural use, and in order to provide a basis for estimating chemical inputs to the hydrologic system, the Grand Traverse County Extension Service compiled information on the amount of field and fruit crops grown in each township in 1988. These data are given in table 5.

Table 4.--Land-use data for Grand Traverse County

[mi^2, square miles; percent, percentage of total area]

Township or city	Residential, mobile home parks		Business district, shopping center, commercial, institutional		Industrial		Transportation, communications, utilities		Cropland, confined feeding operations, permanent pasture, other agricultural lands	
	mi^2	Percent	mi^2	Percent	mi^2	Percent	mi^2	Percent	mi^2	Percent
Acme	1.65	6.75	0.21	0.85	0.042	0.17	0.095	0.39	5.54	22.82
Blair	1.80	4.99	.19	.53	.11	.30	.016	.04	7.12	19.74
Grant	.61	1.69	.0094	.03	.00	.00	.00	.00	11.90	32.94
East Bay	3.54	8.30	.24	.56	.00	.00	.16	.37	3.97	9.32
Fife Lake	.53	1.46	.084	.24	.00	.00	.00	.00	3.96	11.00
Garfield	3.22	11.49	.68	2.43	1.07	3.80	.081	.29	8.28	29.51
Green Lake	1.88	5.34	.41	1.17	.036	.10	.13	.36	1.67	4.75
Long Lake	2.42	6.80	.029	.08	.00	.00	.00	.00	7.37	20.72
Mayfield	.068	.19	.014	.04	.0045	.01	.00	.00	18.17	50.10
Paradise	.73	1.39	.086	.15	.00	.00	.11	.28	10.86	20.53
Peninsula	2.69	9.33	.033	.12	.041	.14	.00	.00	.22	.76
Union	.11	.30	.00	.00	.00	.00	.00	.00	.17	.48
Whitewater	1.08	2.19	.046	.09	.012	.02	.24	.49	3.82	7.75
Traverse City	2.86	35.71	1.27	15.79	.66	8.20	1.15	14.31	.13	1.62

Table 4.--Land-use data for Grand Traverse County--Continued

Township or city	Orchards, bush fruits, vineyards, horticulture area		Herbaceous openland		Northern hardwood, aspen/birch, lowland hardwood, pine, other upland conifers, lowland conifers, managed christmas tree plantation		Streams and waterways, lakes, reservoirs		Other uses	
	mi^2	Percent	mi^2	Percent	mi^2	Percent	mi^2	Percent	mi^2	Percent
Acme	4.60	18.94	3.24	13.34	6.26	25.76	0.14	0.59	2.70	10.39
Blair	.55	1.52	6.95	19.29	17.00	47.16	.35	.97	1.97	5.46
Grant	.00	.00	3.36	9.28	18.33	50.54	.73	2.02	1.27	3.50
East Bay	1.11	2.61	4.41	10.34	23.82	55.85	2.50	5.86	2.90	6.79
Fife Lake	.00	.00	2.00	5.55	26.03	72.32	1.24	3.43	2.16	6.00
Garfield	.94	3.35	4.40	15.67	5.34	19.03	1.03	3.69	3.01	10.74
Green Lake	.030	.09	3.54	10.09	17.60	50.12	6.34	18.05	3.49	9.93
Long Lake	.19	.53	4.21	11.83	13.65	38.36	5.83	16.38	1.88	5.30
Mayfield	.00	.00	3.27	9.02	12.74	35.12	.15	.40	1.87	5.12
Paradise	.12	.22	7.17	13.56	30.84	58.31	.058	.11	2.92	5.45
Peninsula	14.28	49.54	2.27	7.88	6.97	24.17	.88	3.06	1.44	5.00
Union	.00	.00	1.55	4.29	32.25	89.32	.19	.54	1.83	5.07
Whitewater	3.33	6.74	4.89	9.91	30.91	62.62	.54	1.10	4.49	9.09
Traverse City	.0097	.12	.50	2.35	.57	7.10	.32	3.97	.55	10.83

APPENDIX D

HYDROGEOLOGICAL STUDY
OF A
PROPOSED IRRIGATION FIELD
FOR
GRAY AND COMPANY
AT
WILLIAMSBURG, MICHIGAN

by
Nordlund and Associates, Inc.
September 1988

INCLUDING:
DECEMBER 8, 1989 SUPPLEMENT

HYDROGEOLOGICAL STUDY

OF A

PROPOSED IRRIGATION FIELD

FOR

GRAY AND COMPANY

AT

WILLIAMSBURG, MICHIGAN

Prepared By

NORDLUND AND ASSOCIATES, INC.
Consulting Engineers and Surveyors
813 East Ludington Avenue
Ludington, MI 49431

September 1988

File: 81-4

HYDROGEOLGOCIAL STUDY
GRAY AND COMPANY'S
WILLIAMSBURG PLANT

INDEX

LIST OF EXHIBITS

General Site Plan located in back pocket.

HYDROGEOLOGICAL STUDY
GRAY AND COMPANY'S
WILLIAMSBURG PLANT

A. INTRODUCTION

The purpose for this investigation is to determine whether a proposed irrigation field, located near Gray and Company's Williamsburg Plant, is technically feasible. In order to evaluate the hydro-geological properties of the subsurface soils at the proposed site, an exploration program consisting of: site topography, ground water elevations, soil borings, installation of monitor wells, and ground water samples have been taken. A major source of aquifer information has also been derived from a pump test taken at this site. The information from these tests and measurements has been evaluated and used to determine whether the site is appropriate for it's proposed use as an irrigation field for maraschino cherry wastes.

Gray and Company is a maraschino processor with their production facilities located in Hart, Michigan. Gray and Company receives the bulk of it's cherries for processing from the Grand Traverse area, and at the present time, has a number of receiving stations located in Grand Traverse County. At a receiving station for cherries used for maraschino cherry production, the cherries are put into a pit in the ground that is lined with an impervious liner and submerged in a brine solution. The cherries are then hauled to the processing plant in tank trucks while suspended in the brine solution. The present practice is to dispose of all of the brine solution produced at the receiving stations into the City of Hart's Municipal Wastewater Treatment Plant. This practice entails not only the transporting to Hart of the cherries that are submerged in the brine solution, but also the brine remaining in the pits after all of the cherries are removed is at the present time hauled to and disposed of at the City's Treatment Facilities.

The City of Hart's Sewerage Treatment Facility was designed and constructed to treat a combination of domestic and industrial wastes from the Fruit and Vegestable Industry. The growth of the Fruit and Vegetable Industry in the City of Hart has been phenominal and the plant is grossly overloaded. All of the industrial users of the system have been given orders by the City to limit wastewater flows and an order mandating maximum flows and strengths from each industry has been issued by the City of Hart. As a result of this overloading, the City of Hart's treatment facility has discharged raw or partialy treated

sewage to a stream adjacent to the treatment facility and the plant has a serious odor problem.

Nordlund and Associates, Inc. conducted a study of Gray's processing facility in Hart to determine what measures could be taken to reduce flows and strengths at the plant. Some of the conclusions of the study were that if the hauling of the brine remaining in the storage pits in Grank traverse County was eliminated, and if the excess brine that is hauled in with the cherries and the first flush from the leaching operation is captured and removed from the City system; the flows would be reduced approximately 1 percent, but a 12 percent reduction in BOD would be realized.

Additionally, the operation of the irrigation field will allow future expansions at the Williamsburg Plant. This would be beneficial to Gray and Company and provide additional jobs for the surrounding area.

B. PROPOSED SITE LOCATION

The Gray and Company Williamsburg Plant is located in the Southeast 1/4 of Section 9, T28N, R9W, Whitewater Township, Grand Traverse County, Michigan. The proposed irrigation field is located adjacent to the existing plant in Section 9. Please refer to Exhibits numbered 1,2 and 3 in the appendix and also the General Site Plan, located in the back pocket, for more information.

C. CONCLUSION OF THE INVESTIGATION

The proposed irrigation field required is 4.5 acres in size. The dimensions and the location of this field are shown on the General Site Plan. The field should be equipped with orbital sprinklers which will allow total coverage of the site.

A grass forage crop consisiting of either clover or Red Fescue is recommended. This crop is tolerant to chlorides and may be periodically cut and marketed for resale in order to recover some of the costs of the operation and remove potential nutrient loadings from the irrigation field through decaying vegetation.

The four existing and two proposed monitoring wells located around the perimeter of the proposed irrigation field will be adequate to monitor the quality of the ground water both upgradient and downgradient of the proposed site.

The impact of the additional irrigation will create an artificial mound of water 2 feet high at the center of the proposed site. It is felt that the height of this mound will not be significant as the depth to ground water is approximately 10 feet minimum.

Currently, other than Mr. Keith Hubbell's irrigation well (Exhibit 8 - Well E), there does not exist any public or private wells located downgradient of the proposed facility. It should be noted that this well, as well as the other wells logged in Exhibit 8, are completed to an aquifer that is located below a clay layer, and not into the upper aquifer to which the facility will discharge.

In conclusion, the proposed irrigation field will alleviate wastewater disposal problems at Hart, Michigan, will have no serious impacts the ground water, and will allow the Gray and Company's Williamsburg Plant to expand. When all of the impacts of installing this facility are considered, it is obvious that the proposed irrigation field will have a positive impact on both the environment and economy of the State of Michigan.

D. RECOMMENDATION:

The proposed irrigation field will be operated by a pump capable of providing a flow rate of 130 gallons per minute at a static head of approximately 180 feet depending on the sprinkler system pressure required. The pump must be able to function in the corrosive brine waste water. The sprinkling system should be designed to operate for eight hours a day, five days a week, from May 1st to October 31st. The sprinkling should occur between the hours of 8:00 a.m. to 4:00 p.m. to allow maximum evaporation to occur. In order to balance the hydraulic load, the system should be run longer during dry periods and for shorter periods during wet weather.

Ground cover on the irrigation field should consist of Red Fescue, clover or other suitable vegetation. These are plants which can tolerate moderately high concentrations of salt. The plants should be periodically harvested which will remove some of the B.O.D. and total hydraulic loading at the site. Also, the sale of the harvest will allow the operators to recover some of the costs of the irrigation field.

Presently two monitor wells are located downstream of the proposed irrigation field, two wells are located upstream of it, and an additional upstream and downstream well is proposed. These six wells will provide adequate background information and also monitor any possible contamination.

Additional work proposed as a result of this report would be the purchase and installation of an irrigation system consisting of:

a. 130 gpm pump and ancilliary equipment
b. A wet well of sufficient size to allow a 10 to 1 dilution of the receiving waste. If a tanker of 6,000 gallons is being delivered for disposal, a wet well of approximately 66,000 gallons is required, which is approximatly one day of irrigation at the above rates. A pit similar to those utilized for marachino cherries could be utilized for this wet well.
c. The instillation of a chloride meter and recorder, and a flow meter on the pump discharge line so that proper flow data and loadings may be verified.
d. PVC or equal piping system which would be able to withstand the corrosiveness of the waste water.
e. Sprinkler system capable of providing total coverage of the irrigation site.
f. Planting of Red Fescue or clover ground cover, or equal.
g. Two additional observation wells

E. CHLORIDE LOADING CAPACITY

The proposed irrigation field will be planted with a moderately salt tolerant forage crop, such as Clover or Red Fescue. This species can tolerate an electrical conductivity between 3.0 to 6.0 mmho/cm. or the corresponding chloride concentration of 1920 - 3840 ppm.

The elimination of the waste brine hauling and the return of waste brine from the Hart Facility will generate 280,000 gallons per year with an estimated chloride concentration of 4,000 ppm. The capture of the first leach and hauling opertion will generate 432,000 gallons per year with an estimated chloride concentration of 2,000 ppm. The average concentration is therefore approximately 2,800 ppm. As it is recommended that the chloride concentration of the water, as applied, be limited to 250 ppm; it will be necessary to dilute the brine solution to approximately 8 million gallons per year. It should be noted that the dilution water does not necessarily need to be well water, it may be process water, providing that the water is sufficiently low in chlorides so that the 250 ppm concentration is not exceeded and the waters contain no substances that would be unsuitable for irrigation.

In addition, it is conservatively estimated that during the 180 day irrigation season, a total of 12 inches of rain will occur. This will create roughly 1.5 million gallons of rain on the proposed four and one half acre irrigation field and reduce the estimated chloride load by 16 percent.

F. ESTIMATED HEIGHT Of GROUND WATER:

The maximum height of the artificial mound resulting in response to the irrigation rate at the Williamsburg proposed irrigation site was calculated as follows:

$$hm - hi = \frac{0.5\ Wmt}{15\ Sy} \quad [4W^*]$$

where hi = initial height of water table above aquiclude, in feet
hm = height of water table above aquiclude with recharge, in feet
Wm = recharge rate, in gpd per unit area (sq. ft.)= 8,000,000 ÷ (180) ÷ (43,560 x 4.5) = 0.227
t = time after recharge starts, in days
S = specific yield of aquifer, fraction
bm = one-half width of recharge area, in feet
T = coefficient of transmissibility, in gpd/ft
am = one-half length of recharge area, in feet

The function W* is taken from Table 6.2 page 371 of "Ground Water Resource Evaluation." It is necessary to calculate αm and βm before table 6.2 may be used however.

$$\alpha m = 1.37(am)\frac{(S)^{\frac{1}{2}}}{(T_t)}$$

$$\beta m = 1.37(bm)\frac{(S)^{\frac{1}{2}}}{(Tt)}$$

The system is rectangular in shape am = 210' bm = 235 feet

$$\alpha m = (1.37)(210)\left[\frac{0.014}{13{,}780 \times 180}\right]^{\frac{1}{2}} = 0.022$$

$$\beta m = (1.37)(235)\left[\frac{0.014}{13{,}780 \times 180}\right]^{\frac{1}{2}} = 0.024$$

This results in W* = .0050 (estimated)

$$hm - hi = \frac{0.5\ Wmt}{15\ S}\left[4W^*\right]$$

$$= \frac{(0.5)(0.227)(180)(4)(.0050)}{(15)(.014)}$$

=1.95 feet or approximately 2 feet Rise in water level

G. DATA PRESENTATION:

1. Method of Data Collection and Procedure:

Three inch monitor wells were installed by Technical Drilling service. They also provided the soil borings for these wells, labeled "A", "B" and "C". The driller used a continuous flight 2 inch solid anger to install the wells and obtain soil information. The soil boring logs are included in the appendix as Exhibit Number 4.

The depth to the ground water level was determined using an electronic water seeking probe. Elevations in the proposed irrigation field were set using a standard surveyor's level and telescoping level rod. Elevations used are U.S.G.S. established as noted on the site plan. Water samples were taken of the three observation wells and analyzed by Aquatic Systems; the results of which is shown in Exhibit Number 5.

Unfortunately, the well driller who installed the 4 inch production well and well "D" neglected to take soil boring information. The production well was installed with a submersible pump capable of pumping between 20-30 gallons per minute. A power supply for this well was provided by an outlet on a nearby control panel and 200 feet of extension chord.

During the pump tests flow information was provided by an orifice bucket, and the discharged water was removed from the site with approximately 70 feet of 6 inch sewer pipe. Once again, water levels were determined using the electronic water seeking probe. All of the pump test information is located in Exhibit Number 6.

2. Soil Borings:

When this job was initially started, it was assumed that the groundwater would flow Westerly or Northwesterly toward Tobego Creek, located 1,800 feet West of the proposed site. However, instead of a groundwater gradiant Westerly, the results from the monitor well installation shows the direction of the groundwater gradiant to be almost directly North. When a profile of the known groundwater surfaces is plotted, (refer to Exhibit 7) the possibility of a perched water table is strongly suggested.

There are no water supplies drawn from this perched aquifer, other than irrigation water, and it is very doubtful that this will ever occur. Therefore, it must be assumed that the natural conditions of this aquifer makes it a good receiving system for the irrigation field.

3. Discussion of Pump Test Results:

The results of the pump test reveals interesting information about the aquifer. First, the aquifer is located in a medium to fine silty sand, which is layered with several clayey and silty seams. The combination of these two soil conditions had a considerable effect on the pump test.

The shape of the drawdown verses time curves for the pump test revealed that the slow draining characteristic of the soil and the presence of the relatively impervous layer affected the plots. The basic equation for aquifer calculations assumes that the horizontal and vertical permeability components must be equal. However, due to the relatively impervious clay and silt seams, this conditions does not exist. An explanation of how to best address this situation has been included in this report as Exhibit Number 6.

After the explanation discussed in Exhibit Number 6 is applied to the graphs, a reasonable correspondence between Wells "B" and "C" exists. This allows the calculation of the storativity coefficient and transmisivity of 0.014 and 13,780 gallons per day per foot respectively.

Pages 84-90 Exemption 9

ASI, ENVIRONMENTAL TECHNOLOGIES
1100 Conrad Industrial Drive • P.O. Box 649 • Ludington, MI 49431 • Phone (616) 845-0371

July 29, 1988

AUG 4 1988

Nordland & Associates
813 E. Ludington Avenue
Ludington, MI 49431
Attn: Mr. Jim Nordland

Dear Mr. Nordland:

Please find enclosed your analytical results for your water sample. Analysis was performed in accordance with the methods in the "Federal Register", Vol. 49, No. 209, Friday, October 26, 1984, "U.S. EPA Methods for Chemical Analysis of Water and Wastes", (EPA-600/4-79-020) March, 1983, "Standard Methods for the Analysis of Water and Wastewater", 16th Edition, or "Test Methods for Evaluating Solid Wastes", U.S. EPA, September, 1986.

ASI REF. NO.: 81232

If you have any questions concerning these results, please do not hesitate to contact our laboratory at (616) 845-0371.

Sincerely,

ASI, Analytical Services Division

Doug Conran
Lab Director

tlm

Enclosure

Saginaw Branch
P.O. Box 2426
Saginaw, Michigan 48605
(517) 792-0230

Holland Branch
P.O. Box 2068
Holland, Michigan 49422
(616) 399-5255

Chicago Branch
772 West Algonquin
Arlington Heights, Illinois 6000[illegible]
(312) 364-7571

EXHIBIT K

AUG 4 1988

ANALYTICAL SERVICES

PROJECT:	Gray & Company	DATE SAMPLED:	07/01/88
ASI REF. NO.:	81232	DATE RECEIVED:	07/06/88
SAMPLED BY:	Nordland & Associates	DATE FINISHED:	07/28/88
DESCRIPTION:	Water Sample	REPORT DATE:	08/01/88
ANALYST:	DS, MD, DD, LS		

ASI SAMPLE I.D.:	4388	4389	4390
CLIENT SAMPLE I.D.:	A 81-4	B 81-4	C 81-4
CALCIUM, mg/L	42	34	40
IRON, mg/L	25	14	5.8
MAGNESIUM, mg/L	12.5	23.4	19.1
POTASSIUM, mg/L	8.32	5.68	1.92
SODIUM, mg/L	2.44	2.36	2.14
BICARBONATE, mg Equiv. CaCO3/L	138	138	147
CARBONATE, mg Equiv. CaCO3/L	<10	<10	<10
CONDUCTIVITY @ 25C umhos/cm	303	249	334
CHLORIDE, mg/L	0.2	<1	<1
FLOURIDE, mg/L	0.062	0.217	0.187
HARDNESS, mg CaCO3/L	162	131	192
AMMONIA-N, mg/L	0.12	0.13	0.13
NITRATE-N, mg/L	2.6	0.28	0.56
NITRITE-N, mg/L	0.023	0.016	0.006
TOTAL PHOSPHORUS, mg/L	0.185	0.581	0.075
SULFATE, mg/L	12	10	9

Doug Conran

Doug Conran
Lab Director

ASI

EXHIBIT K

EXHIBIT 6

On September 2, 1988, a pumping test was conducted at the Williamsburg Plant to determine aquifer constants to be utilized in the groundwater mounding calculations. The pump was operated to produce a constant flow of 21.4 gallons per minute.

There are problems associated with direct interpretation of the data as the aquifer is not uniform in character and the hydraulic conductivity is not the same in all directions. The type of curve plotted for the pumped well is called a slow drainage curve and is typical of an aquifer with layers of various permeabilities. With the exception of residual drawdown is Well C, the drawdown, recovery and residual drawdown curves were plotted for all three wells. The slope of the drawdown curve varied wildly from 0.056 feet to 2.7 feet. After analysis of the plots, the results for Observation Well B were chosen as being most representative for the following reasons:

The measurements in Well C are too small to make accurate predictions. Changes in atmospheric pressure and minor errors in reading of the water level measurements or leveling can greatly influence the results.

The pumped well has considerable turbulence due to the pumping activity and the measurements can be affected by this phenomenon, plus the pumped well is sensitive to small changes in pump output.

Finally, the slope of the curves was most constant for all three data plots for Well B

Utilizing a slope of 0.41 from and an intercept of 4.5 minutes from the drawdown curve, the following data can be calculated.

$$T = \frac{264 \times 21.4}{0.41} = 13{,}780 \text{ gpd per foot}$$

$$S = \frac{0.3 \times 13{,}780 \times 4.5}{30.4^2 \ (1440)} = 0.014$$

It should be noted that the t/t' intercept at zero drawdown on Well B's residual drawdown plot is large, which is indicative of recharge to the aquifer. Vertical nonuniformity in an aquifer is similar to vertical infiltration into the aquifer and will give a similar dislocation to this curve.

PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG, MICH.

DRAWDOWN
PUMPED WELL

9-2-88

ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	DRAWDOWN
11 :11 .00	25.50	1.00 MINUTES	10.85
11 :14 . 9	26.65	4.15 MINUTES	12
11 :17 .18	26.78	7.30 MINUTES	12.13
11 :21 .41	26.93	11.68 MINUTES	12.28
11 :25 . 9	26.93	15.15 MINUTES	12.28
11 :30 .27	27.00	20.45 MINUTES	12.35
11 :38 .42	27.17	28.70 MINUTES	12.52
11 :51 .16	27.33	41.27 MINUTES	12.68
11 :58 .32	27.33	48.53 MINUTES	12.68
12 : 7 .11	27.42	57.18 MINUTES	12.77
12 :18 .37	27.46	68.62 MINUTES	12.81
12 :30 .59	27.58	80.98 MINUTES	12.93
12 :45 .53	27.63	95.88 MINUTES	12.98
12 :57 .39	27.73	107.65 MINUTES	13.08
13 :32 .28	27.88	142.47 MINUTES	13.23
14 : 1 .52	27.95	171.87 MINUTES	13.3
14 :54 .25	28.13	224.42 MINUTES	13.48
16 : 4 .32	28.44	294.53 MINUTES	13.79
16 :57 . 2	28.54	347.03 MINUTES	13.89
18 : 0 .27	28.73	410.45 MINUTES	14.08
18 :57 .26	28.81	467.43 MINUTES	14.16

EXHIBIT II

PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG, MICH.

DRAWDOWN
WELL B

9-2-88

ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	DRAWDOWN
11 :15 .56	14.11	5.93 MINUTES	0.05
11 :23 . 9	14.25	13.15 MINUTES	0.19
11 :28 .21	14.56	18.35 MINUTES	0.5
11 :36 .25	14.57	26.42 MINUTES	0.51
11 :52 .19	14.63	42.32 MINUTES	0.57
12 : 1 51	14.67	51.85 MINUTES	0.61
12 : 9 .50	14.70	59.83 MINUTES	0.64
12 :21 34	14.71	71.57 MINUTES	0.65
12 34 .35	14.72	84.58 MINUTES	0.66
12 :48 .39	14.75	98.65 MINUTES	0.69
13 : 1 .46	14.75	111.77 MINUTES	0.69
13 :35 .19	14.76	145.32 MINUTES	0.7
14 : 5 .50	14.79	175.83 MINUTES	0.73
14 :58 .30	14.79	228.50 MINUTES	0.73
16 : 6 .19	14.82	296.32 MINUTES	0.76
16 :59 .00	14.84	349.00 MINUTES	0.78
18 : 3 .35	14.87	413.58 MINUTES	0.81
19 : 0 .52	14.88	470.87 MINUTES	0.82

EXHIBIT VI

PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG, MICH.

DRAWDOWN 9-2-88
WELL C

ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	DRAWDOWN
11 :13 .29	17.10	3.48 MINUTES	-0.09
11 :20 . 9	17.10	10.24 MINUTES	-0.09
11 :26 .37	17.20	16.99 MINUTES	0.01
11 :31 .56	17.25	21.93 MINUTES	0.06
11 :40 .00	17.16	30.00 MINUTES	-0.03
11 :49 .38	17.16	39.63 MINUTES	-0.03
12 : 0 . 8	17.16	50.13 MINUTES	-0.03
12 : 8 .27	17.22	58.45 MINUTES	0.03
12 :20 .15	17.18	70.25 MINUTES	-0.01
12 :32 .54	17.27	82.90 MINUTES	0.08
12 :47 .12	17.20	97.20 MINUTES	0.01
12 :59 .37	17.22	109.62 MINUTES	0.03
13 :34 . 2	17.27	144.03 MINUTES	0.08
14 : 3 .52	17.26	173.87 MINUTES	0.07
14 :56 .24	17.25	226.40 MINUTES	0.06
16 : 9 . 1	17.27	299.02 MINUTES	0.08
17 : 0 .59	17.29	350.98 MINUTES	0.1
18 : 2 . 8	17.31	412.13 MINUTES	0.12
18 :59 . 9	17.33	469.15 MINUTES	0.14

EXHIBIT VI

PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG, MICH.

REBOUND
PUMPED WELL

9-2-88

ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	RESIDUAL DRAWDOWN
19 : 6 .45	17.21	1.75 MINUTES	2.56
19 : 7 .58	17.35	2.97 MINUTES	2.7
19 :10 .37	16.15	5.62 MINUTES	1.5
19 :13 .14	15.63	8.23 MINUTES	0.98
19 :17 . 9	15.00	12.15 MINUTES	0.35
19 :19 .56	14.99	14.93 MINUTES	0.34
19 :25 . 0	14.97	20.00 MINUTES	0.32
19 :30 . 0	14.95	25.00 MINUTES	0.3
19 :35 .10	14.92	30.17 MINUTES	0.27
19 :40 . 0	14.90	35.00 MINUTES	0.25
19 :50 . 0	14.89	45.00 MINUTES	0.24
20 : 0 . 0	14.88	55.00 MINUTES	0.23
20 :10 .33	14.86	65.55 MINUTES	0.21
20 :25 . 0	14.84	80.00 MINUTES	0.19
20 :39 .20	14.84	94.33 MINUTES	0.19

Exhibit VI

PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG. MICH.

REBOUND
WELL "B"

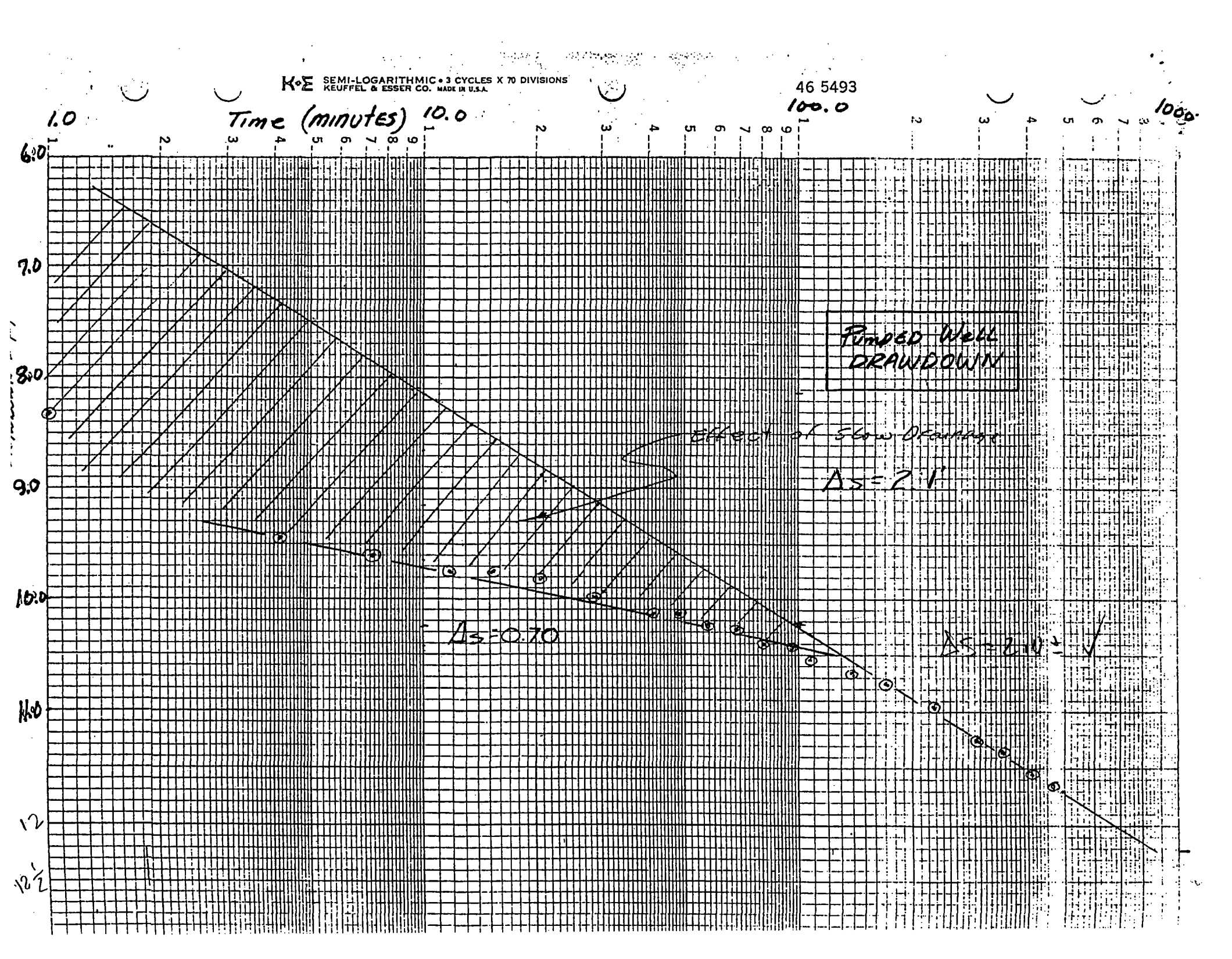
ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	RESIDUAL DRAWDOWN
19 : 7 .17	14.58	2.28 MINUTES	0.52
19 : 9 .41	14.40	4.68 MINUTES	0.34
19 12 . 1	14.30	7.02 MINUTES	0.24
19 :15 .51	14.22	10.85 MINUTES	0.16
19 :25 .41	14.15	20.68 MINUTES	0.09
19 :30 .26	14.10	25.43 MINUTES	0.04
19 :35 .41	14.10	30.68 MINUTES	0.04
19 :40 .37	14.07	35.62 MINUTES	0.01
19 :50 .49	14.07	45.82 MINUTES	0.01
20 : 0 .29	14.06	55.48 MINUTES	0
20 :11 .18	14.05	66.30 MINUTES	-0.01
20 :25 .39	14.03	80.65 MINUTES	-0.03
20 :40 .10	14.04	95.17 MINUTES	-0.02
21 :11 .13	14.04	126.22 MINUTES	-0.02

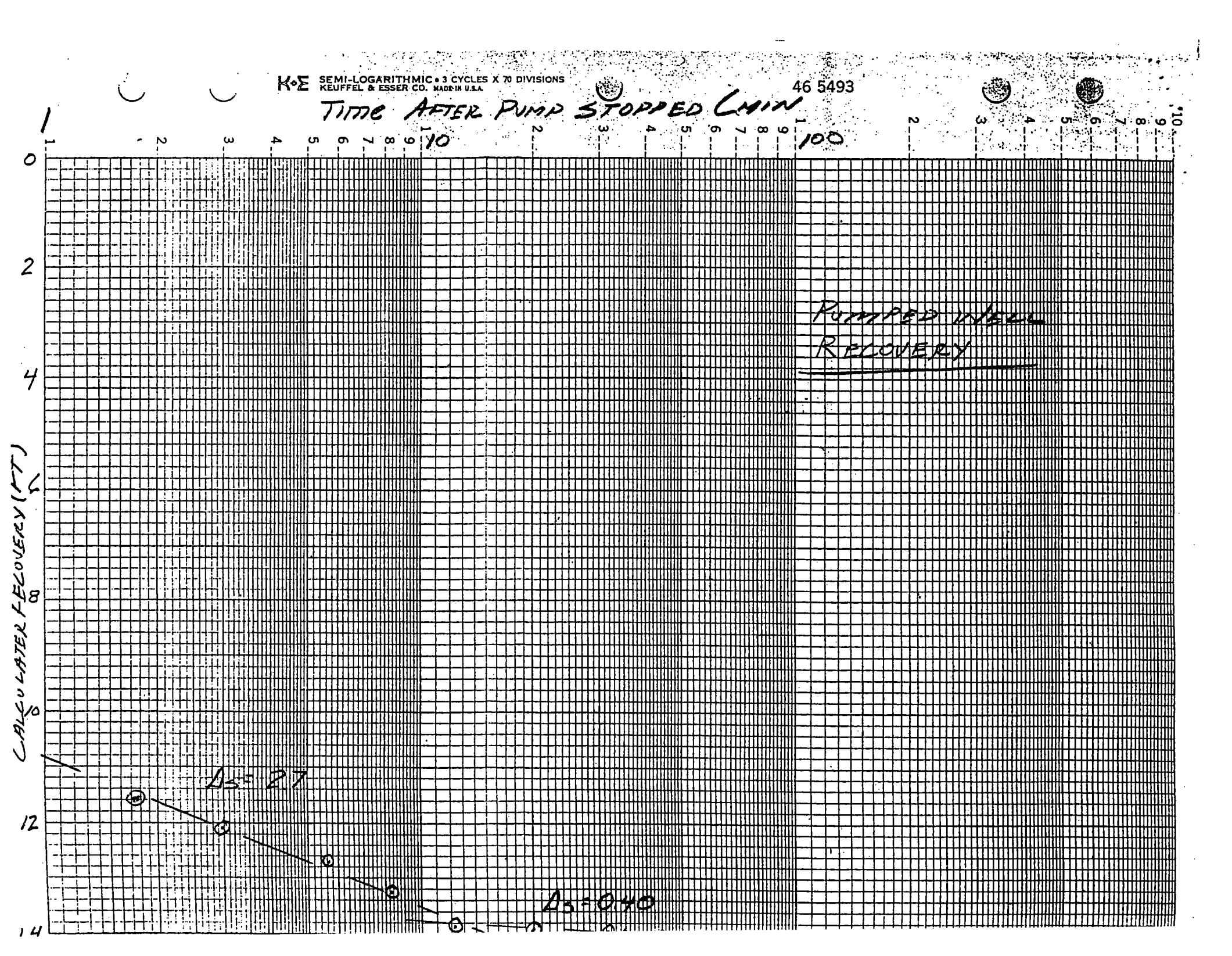
EXHIBIT VI

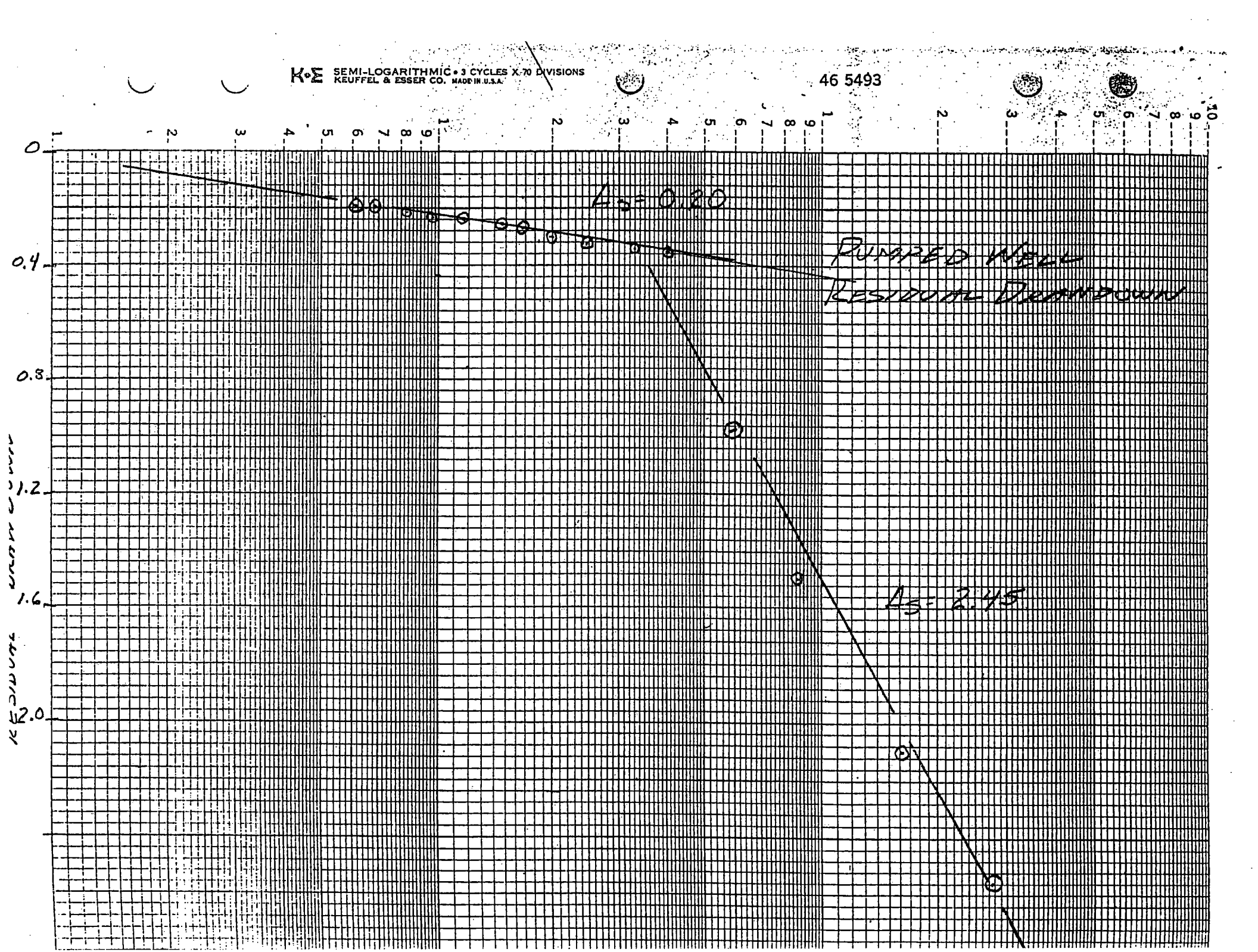
PUMP TEST RESULTS - GRAY & CO. - WILLIAMSBURG, MICH.

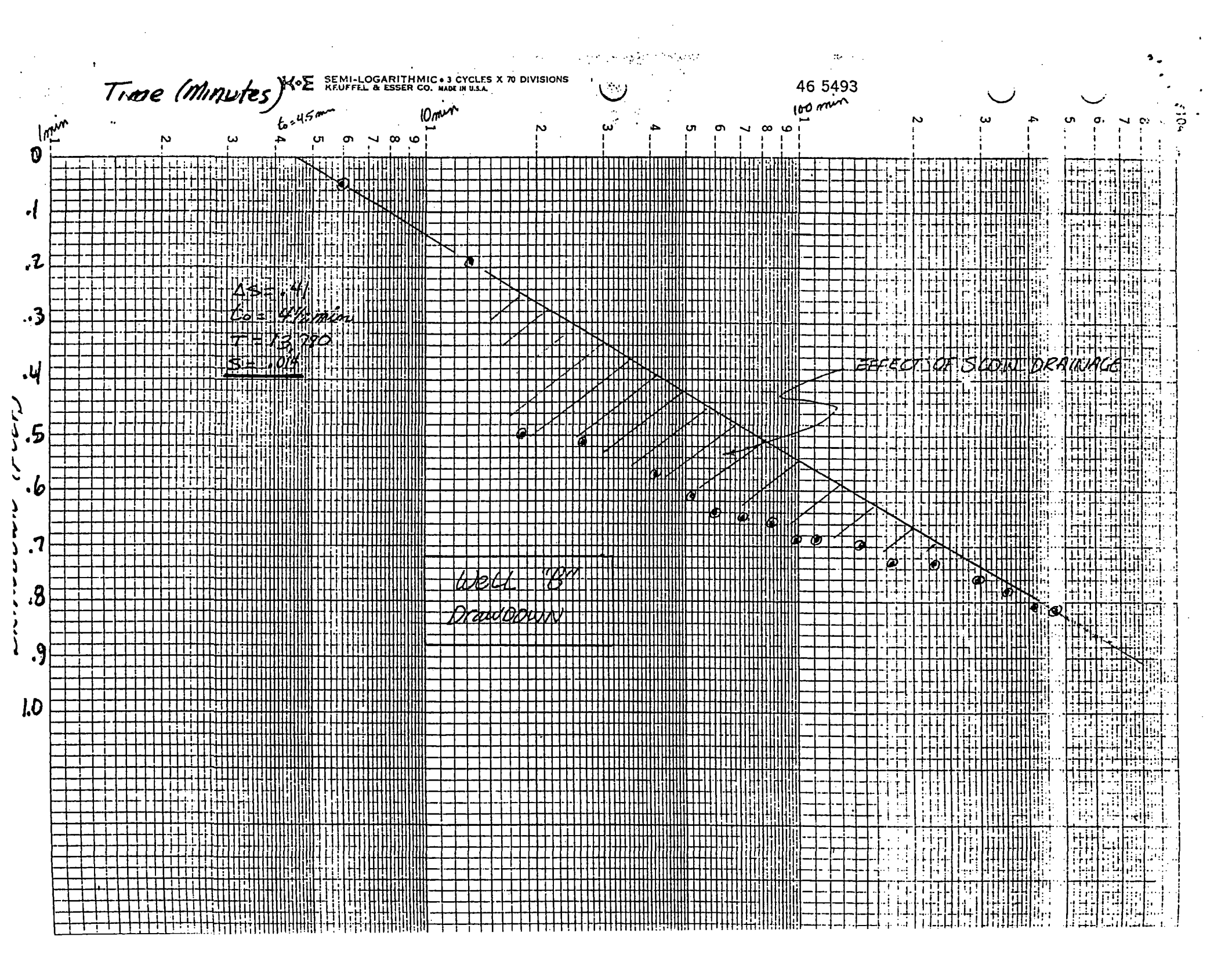
REBOUND
WELL "C"

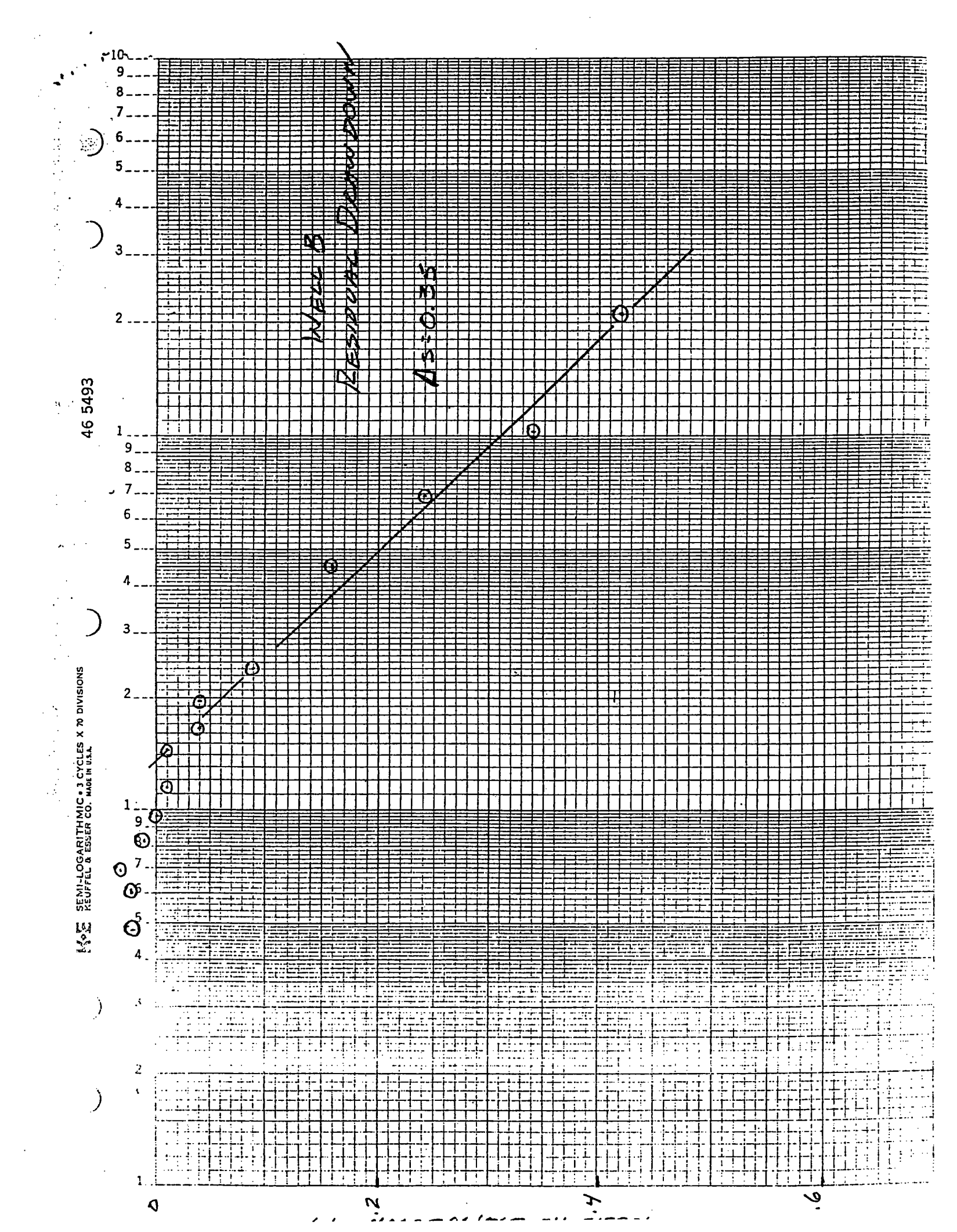
ACTUAL TIME	DEPTH TO WATER	ELAPSED TIME	RESIDUAL DRAWDOWN
19 : 8 .51	17.33	3.85 MINUTES	0.14
19 :11 .24	17.31	6.40 MINUTES	0.12
19 :14 .11	17.32	9.18 MINUTES	0.13
19 :18 .52	17.31	13.87 MINUTES	0.12
19 :27 . 2	17.31	22.03 MINUTES	0.12
19 :31 .55	17.31	26.92 MINUTES	0.12
19 :37 .34	17.31	32.57 MINUTES	0.12
19 :42 .15	17.31	37.25 MINUTES	0.12
19 :52 .14	17.29	47.23 MINUTES	0.1
20 : 1 .57	17.29	56.95 MINUTES	0.1
20 :13 .14	17.29	65.23 MINUTES	0.1
20 :27 .15	17.26	82.25 MINUTES	0.07
20 :42 .10	17.26	97.17 MINUTES	0.07
21 : 7 .39	17.27	122.65 MINUTES	0.08

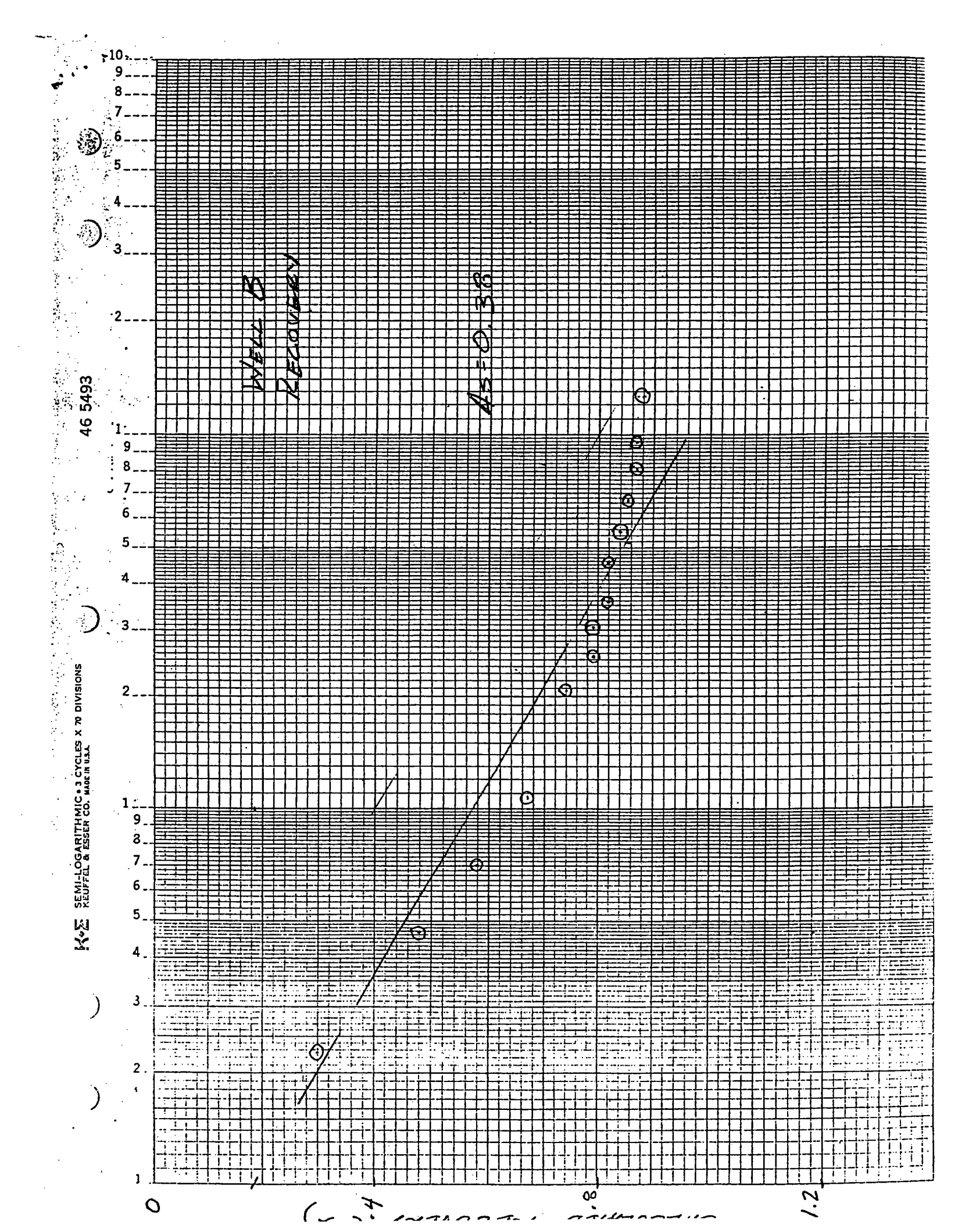

K•E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5493
Time (minutes)
1.0
10.0
100.0
1000.
6.0
7.0
8.0
9.0
10.0
11.0
12
12½
Pumped Well
DRAWDOWN
Effect of slow drainage
Δs = 2.1'
Δs = 0.70
Δs = 2.1' + √

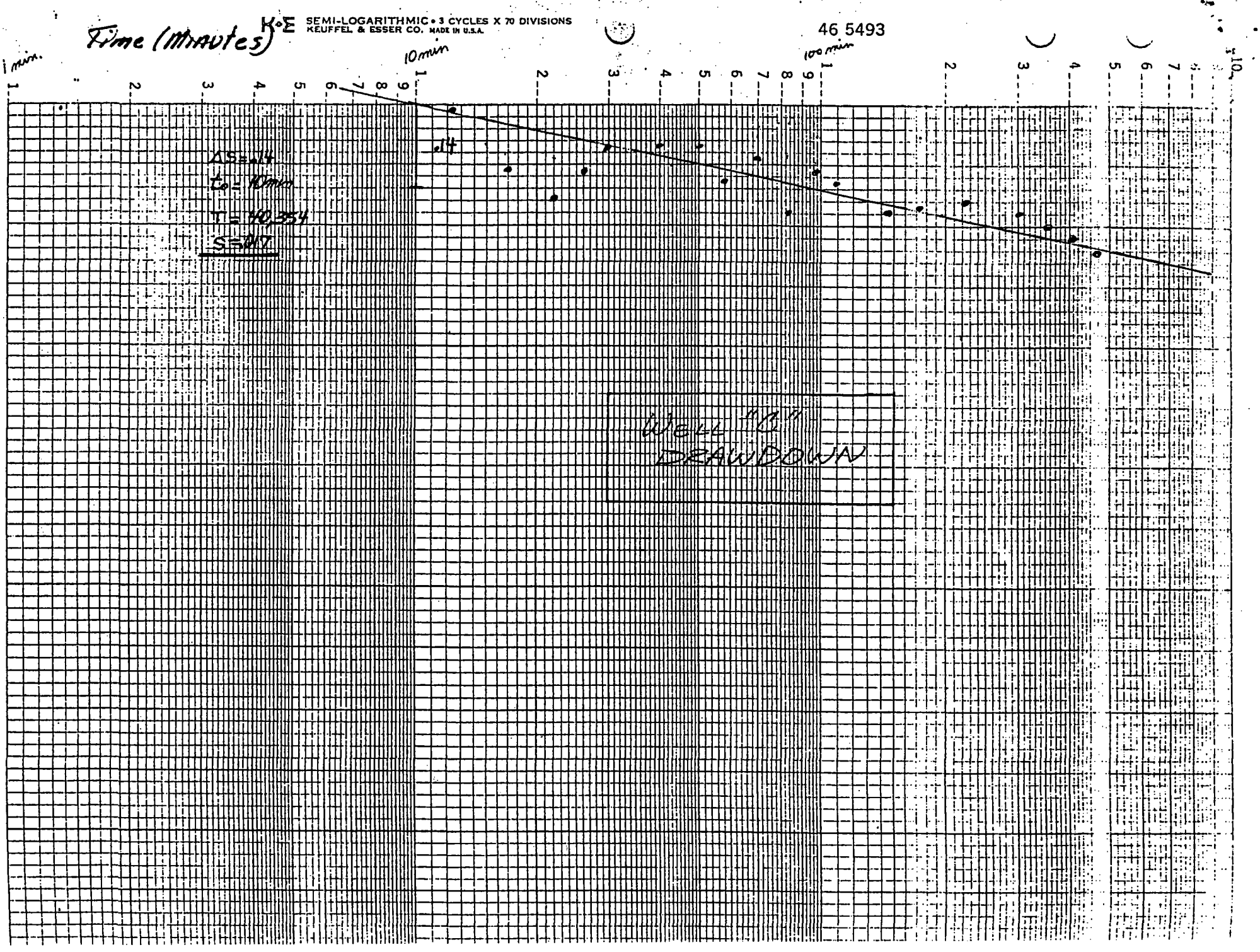

K•E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5493
TIME AFTER PUMP STOPPED (MIN)
CALCULATED RECOVERY (FT)
PUMPED WELL
RECOVERY
Δs = 27
Δs = 0.40

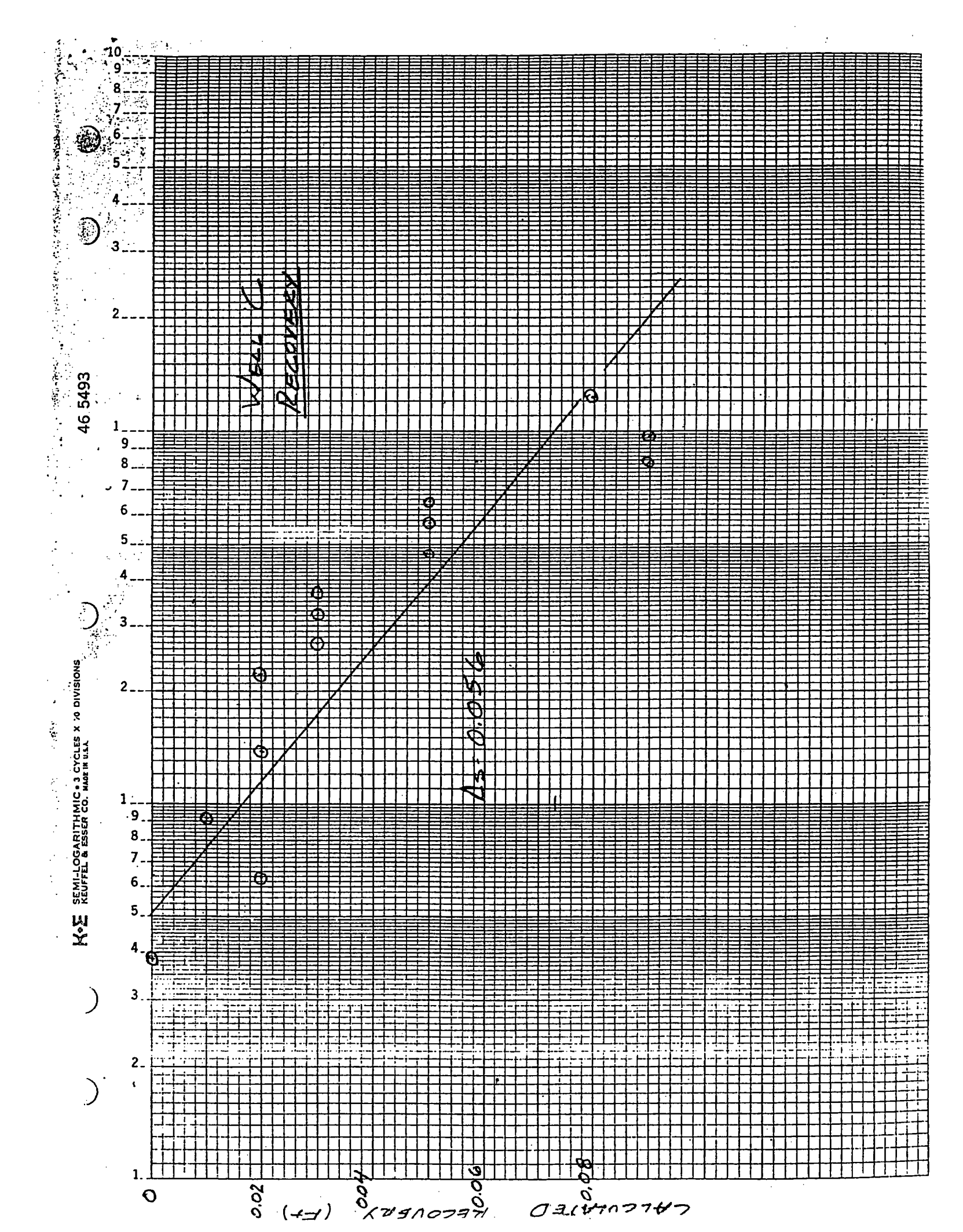

K&E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5493
0
0.4
0.8
1.2
1.6
2.0
Δ2 = 0.20
Δ5 = 2.45
Pumped Well
Recovery Drawdown


Time (Minutes)
K&E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5493
t_0 = 4.5 min
1 min
10 min
100 min
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
Δs = .41
C_0 = 91 gpm/min
T = 13,290
S = .014
EFFECT OF SLOW DRAINAGE
WELL "B"
DRAWDOWN


Well 8
Residual Drawdown
$\Delta s = 0.35$
46 5493
SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
10
9
8
7
6
5
4
3
2
1
0
2
4
6


Well 8
Recovery
$\Delta s = 0.38$
46 5493
K&E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
10
9
8
7
6
5
4
3
2
1
0
1.2


Time (Minutes)
K&E SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 5493
1 min.
10 min
100 min
Δs=.14
t₀=1 min
T=40,354
S=.07
.14
WELL "C"
DRAWDOWN


46 5493
K+E
SEMI-LOGARITHMIC • 3 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
Well U
Recovery
As=0.056
CALCULATED RECOVERY (Ft)
0
0.02
0.04
0.06
0.08

Pages 108-114 Exemption 9

NORDLUND & ASSOCIATES, INC.

CONSULTING ENGINEERS AND SURVEYORS

813 E. LUDINGTON AVENUE / LUDINGTON, MICHIGAN 49431

TELEPHONE (616) 843-3485

PRINCIPALS

James T. Nordlund, Sr., P.E., R.L.S.

Richard L. Hays, R.L.S.

STAFF ENGINEERS

James T. Nordlund, Jr.

December 8, 1989

Re: Hydrogeological Study -
Gray & Company
Williamsburg
File: 81-4

Mr. Douglas D. Thompson
Hydrogeological Review Unit
Groundwater Section
Department of Natural Resources
Stevens T. Mason Building
P. O. Box 30028
Lansing, Michigan 48909

Dear Mr. Thompson:

Three additional wells and one soil boring have been completed at the proposed irrigation field of Gray & Company in Williamsburg. Enclosed are well logs and an expanded irrigation field hydrogeological layout sheet showing this additional information.

Upon examination of the data, it can be seen that this additional information has further reinforced the fact that a complex geological formation is present under the site. I have plotted the direction of groundwater flow under the southerly two fields as South 4° East, using Wells F, G and H, while the direction of groundwater flow under the North field is almost due North. Well E and Boring 3 indicated clay formations, while Well F, which is approximately equidistant from Well E and Boring 3 was, with the exception of clay seams at 20 feet, completed in a granular formation. Well H was completed through a series of sand/clay lenses with the well screen placed in what appeared to be the most productive acquifer. This acquifer is artesian with approximately 10 foot of positive head on the top of the acquifer.

All of this information indicates a subsurface drainage system comprised of various interbeded acquifers, the hydraulic connection of which is unknown. The southerly direction of ground water flow under fields 2 and 3 does not appear to be a regional trend when the topography of the surrounding area is examined; as Elk Lake, Tobeco Creek, and Williamsburg Creek flow Northerly.

When the well locations are examined, Well G, which was completed entirely in a sand and gravel formation, is strategically placed to sample ground water flow from irrigated wells to the North;

while Wells B and D, which were completed to an acquifier under a sandy clay layer, are strategically placed to sample irrigated water flowing from the South. Any lateral spreading of ground water flow will be sampled in the other wells. I believe that the requirement for the establishment of an effective ground water monitoring system has been established.

The proposed effluent quality is as follows:*

Chloride	250 ppm
B.O.D.	4,400 ppm
Suspended Solids	20 ppm
Sulfates as SO_4	340 ppm
pH	6.5
Phosphores	6 ppm

*Values given are with estimated dilution required to maintain a chloride concentration of 250 mg per liter. See original report.

I trust that this concludes the submittal of information required to render a decision on Gray & Company's application for a ground water discharge permit.

If you have any question, please do not hesitate to call.

Very Truly Yours,

NORDLUND AND ASSOCIATES, INC.

James T. Nordlund, P.E.

JTN/ne
Encl.
cc: Jim Jensen

WEST MICHIGAN TESTING, INC. WELL

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG
Client: GRAY AND CO.
Sheet # 1 of 2
Driller: CAMERON BROS.
Inspector: JIM DILLINGHAM
Date Start: 10-17-8
Top of boring elevation: _____
Datum: _____
Date Finish: 10-17-8

Ground Water: APPROX. 18' DEPTH

	Casing:	Sample:	Core:	Tube:
Type	SOLID-STEM AUGER BORING			

Date	Time	Depth	Casing

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
1					SAND (SM), FINE TO MEDIUM, SILTY, CLAYEY, BROWN, MOIST	
2						
3						
4						
5		S-1				
6						
7						
8						
9						9 FT.
10		S-2			CLAY (CL), SILTY, SOME FINE TO COARSE SAND, TRACE GRAVEL, BROWN, MOIST	
11						
12						
13						
14						
15		S-3				
16						
17						
18					▽ WL @ DRILLING (EST.)	▽ 12-2-89
19						
20		S-4				

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. WELL H

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG
Client: GRAY AND CO.
Driller: CAMERON BROS.
Inspector: SIM DILLINGHAM
Top of boring elevation: _____
Datum: _____

Sheet # 2 of 2
Date Start: 10-17-89
Date Finish: 10-17-8

Ground Water: APPROX. 18' DEPTH

Date	Time	Depth	Casing	Type

Casing: | Sample: | Core: | Tube:

SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
21					CLAY (CL), SILTY, SOME FINE TO COARSE SAND, GRAYISH-BROWN, MOIST	
22						
23						23 FT.
24					SAND (SM), FINE TO MEDIUM, SILTY, CLAYEY, GRAYISH-BR., SATURATED	
25						
26						26 FT.
27					CLAY (CL), SILTY, GRAYISH-BROWN, MOIST	
28						28 FT.
29						
30						
31					SAND (SP), FINE TO MEDIUM, TRACE COARSE SAND, TRACE GRAVEL, BROWN, SATURATED	WELL "H" 2' STICK-UP 36' PIPE 3' SCREEN (TOP OF SCREEN AT 34')
32						
33						
34						
35					3' SCREEN	
36						
37		S-5				37 FT.
					CLAY (CL), SILTY, BROWN	
38					BOTTOM OF BORING @	37½ FT.
39						
40						

WEST MICHIGAN TESTING, INC. WELL F

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG Client: GRAY AND CO. Sheet # 1 of 3
Driller: CAMERON BROS. Inspector: JIM DILLINGHAM Date Start: 10-17-89
Top of boring elevation: _____ Datum: _____ Date Finish: 10-17-8

Ground Water: APPROX. 39' DEPTH | Casing: | Sample: | Core: | Tube:

Date	Time	Depth	Casing	Type

SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
1						
2						
3						
4						
5		S-1			SAND (SM), FINE TO MEDIUM, TRACE COARSE SAND, TRACE GRAVEL, SILTY, CLAYEY, BROWN, MOIST	
6						
7						
8						
9						
10		S-2				
11						
12						
13						
14						
15		S-3			GRAVELLY	
16						
17						
18						
19						
20		S-4			SEAMS OF CLAY	

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. - WELL F

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG Client: GRAY AND CO. Sheet # 2 of 3
Driller: CAMERON BROS. Inspector: JIM DILLINGHAM Date Start: 10-17-8
Top of boring elevation: _____ Datum: _____ Date Finish: 10-17-8

Ground Water: APPROX. 39' DEPTH | Casing: | Sample: | Core: | Tube:

Date	Time	Depth	Casing	Type

SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
21						
22		S-5				
23						
24						
25		S-6				
26						
27						
28					SAND (SP-SM), FINE TO MEDIUM, SILTY, BROWN, MOIST (WITH SEAMS OF CLAY)	
29						
30		S-7				
31						
32						
33						
34						
35		S-8				
36						
37						
38						
39					▽ WL @ DRILLING (EST.)	
40		S-9			▼ 12-2-89	

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. WELL F

SOIL BORING LOG

Project: GRAY & CO. -WILLIAMSBURG
Client: GRAY AND CO.
Sheet # 3 of 3
Driller: CAMERON BROS.
Inspector: JIM DILLINGHAM
Date Start: 10-17-8
Top of boring elevation: _____
Datum: _____
Date Finish: 10-17-8

Ground Water: APPROX. 39' DEPTH

	Casing:	Sample:	Core:	Tube:
Type	SOLID-STEM AUGER BORING			

Date	Time	Depth	Casing

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
41					SAND (SP), FINE TO MEDIUM, BROWN, SATHRATED	
42						
43						
44						
45		S-10			3' SCREEN	
46		S-11				46 FT.
47					CLAY (CL), SILTY, BROWN	
48					BOTTOM OF BORING @ 47 FT.	
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						

WELL "F"
2' STICK-UP
45' PIPE
3' SCREEN
(TOP OF SCREEN AT 43')

WEST MICHIGAN TESTING, INC. - WELL G

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG
Client: GRAY AND CO.
Sheet # 1 of 3
Driller: CAMERON BROS.
Inspector: JIM DILLINGHAM
Date Start: 10-17-8
Top of boring elevation: _____
Datum: _____
Date Finish: 10-17-8

Ground Water: APPROX. 50' DEPTH

Date	Time	Depth	Casing	Type	Casing:	Sample:	Core:	Tube:
					SOLID-STEM AUGER BORING			

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
1						
2						
3						
4						
5		S-1			SAND (SM), FINE TO MEDIUM, TRACE GRAVEL, SILTY, CLAYEY, BROWN, MOIST	
6						
7						
8						
9						
10		S-2				
11						
12						
13						
14						
15		S-3				
16						
17						
18						
19						
20		S-4				

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. - WELL G

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG Client: GRAY AND CO. Sheet # 2 of 3
Driller: CAMERON BROS. Inspector: JIM DILLINGHAM Date Start: 10-17-89
Top of boring elevation: _____ Datum: _____ Date Finish: 10-17-89

Ground Water: APPROX. 50' DEPTH Casing: Sample: Core: Tube:

Date	Time	Depth	Casing	Type

SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
21						
22						
23						
24						
25		S-5			SAND (SP), FINE TO MEDIUM, TRACE GRAVEL, BROWN, MOIST	
26						
27						
28						
29						
30		S-6			GRAVELLY	
31						
32						
33						
34						
35		S-7			GRAVELLY	
36						
37						
38						
39						
40		S-8				

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. - WELL G

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG
Client: GRAY AND CO.
Driller: CAMERON BROS.
Inspector: JIM DILLINGHAM
Top of boring elevation: _____
Datum: _____

Sheet # 3 of 3
Date Start: 10-17-89
Date Finish: 10-17-89

Ground Water: APPROX. 50' DEPTH

Date	Time	Depth	Casing	Type

Casing: | Sample: | Core: | Tube:

SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
41						
42						
43						
44						
45		S-9			SAND (SP), FINE TO MEDIUM, BROWN, MOIST (SATURATED BELOW 50 FT.)	
46						
47						
48						
49						
50		S-10			▽ WL @ DRILLING (EST.)	▽ W.L. 12-2-89
51						
52						
53						WELL "G"
54						2' STICK-UP
55		S-11				59' PIPE
56						3' SCREEN
57						(TOP OF SCREEN AT 57')
58					3' SCREEN	
59						
60		S-12			BOTTOM OF BORING @ 60 FT.	

WEST MICHIGAN TESTING, INC. - BORING

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG
Driller: CAMERON BROS.
Top of boring elevation: _____

Client: GRAY AND CO.
Inspector: JIM DILLINGHAM
Datum: _____

Sheet # 1 of 3
Date Start: 10-17-8
Date Finish: 10-17-8

Ground Water: _____

Casing: | Sample: | Core: | Tube:

Date	Time	Depth	Casing	Type
				SOLID-STEM AUGER BORING

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
1					SAND (SM), FINE TO MEDIUM, SILTY, CLAYEY, BROWN, MOIST	
2						
3						
4						
5		S-1				
6						
7						
8						8 FT.
9					CLAY (CL), SILTY, SOME FINE TO COARSE SAND, TRACE GRAVEL, BROWN, MOIST	
10		S-2				
11						
12						
13						
14						
15		S-3				
16						
17						
18						
19						
20		S-4				

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. - BORING 2

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG Client: GRAY AND CO. Sheet # 2 of 3
Driller: CAMERON BROS. Inspector: JIM DILLINGHAM Date Start: 10-17-89
Top of boring elevation: _____ Datum: _____ Date Finish: 10-17-89

Ground Water: _____

Date	Time	Depth	Casing	Type	Casing:	Sample:	Core:	Tube:
					SOLID-STEM AUGER BORING			

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
21						
22						
23						
24						
25		S-5				
26						
27					CLAY (CL), SILTY,	
28					TRACE FINE SAND,	
29					GRAY, MOIST	
30		S-6				
31						
32						
33						
34						
35		S-7				
36						
37						
38						
39						
40		S-8				

CONT. NEXT PAGE

WEST MICHIGAN TESTING, INC. - BORING

SOIL BORING LOG

Project: GRAY & CO. - WILLIAMSBURG Client: GRAY AND CO. Sheet # 3 of 3
Driller: CAMERON BROS. Inspector: JIM DILLINGHAM Date Start: 10-17-89
Top of boring elevation: _____ Datum: _____ Date Finish: 10-17-89

Ground Water: _____

Date	Time	Depth	Casing	Type	Casing:	Sample:	Core:	Tube:
					SOLID-STEM AUGER BORING			

DEPTH FT.	CASING BLOWS	SAMPLE NO.	BLOWS ON SAMPLE SPOON PER 6"	SYMBOL	IDENTIFICATION	REMARKS
41						
42						
43						
44						
45		S-9			CLAY (CL), SILTY, TRACE FINE SAND, BROWN, MOIST	
46						
47						
48						
49						
50		S-10			BOTTOM OF BORING @	50 FT.
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						

APPENDIX E

HYDROGEOLOGICAL ASSESSMENT REPORT
WRS SPRAY IRRIGATION AREAS
JULY, 2002

INLAND SEAS ENGINEERING

PO Box 6820, Traverse City, MI 49696
1755 Barlow Street, Traverse City, MI 49686
Phone (231) 933-4041
Fax (231) 933-4393

October 14, 2002

Mr. Joseph E. Quandt
Zimmerman, Kuhn, Darling, Boyd, Taylor & Quandt
412 South Union Street
Traverse City, Michigan 49684

RE: Hydrogeologic Investigation
Spray Irrigation Area
Williamsburg Receiving and Storage
ISE Project No. 02399084-10E

Dear Mr. Quandt:

In accordance with the assessment work plan included in our June 26, 2002 communication to Michigan Department of Environmental Quality (MDEQ), Inland Seas Engineering, Inc. (ISE) has completed the initial four (4) work tasks proposed (Task 1 through Task 4, inclusive). The assessment activities completed include:

- Soil sampling within each spray irrigation application area,
- Soil sample conductivity and moisture content analyses,
- Laboratory analyses of select soil samples for chloride, sodium, and phosphorus content

The following is a report of the methods utilized in this assessment, the results arising from investigative efforts and the conclusions derived from evaluation of the findings.

INTRODUCTION

In early 2002, Williamsburg Receiving and Storage, LLC (WRS) began developing a sweet cherry finishing process at their receiving, stemming and pitting plant located at 10190 Munro Road in Whitewater Township, Grand Traverse County, Michigan. Finishing wastewaters were commingled with wastewaters from stemming and pitting operations and pumped from the plant to the irrigation pond. At that time, the pond already contained several hundred thousand gallons of stemming and pitting wastewater. The waste character of these two (2) processes is essentially the same as the genesis of each is realized by the contact of conveyance and wash waters with brined sweet cherries. The only significant difference between the waste streams lie in the concentrations of natural sugars and dissolved solids. Finishing wastewater contains significantly greater concentrations of brined sweet cherry constituents. Cherry finishing wastewater may also contain trace concentrations of natural sweeteners, such as corn syrup and food-quality coloring pigments absent in stemming and pitting wastewaters.

In March of 2002, spray irrigation of irrigation pond wastewater commenced, with effluent sampling conducted in general conformance with WRS' Wastewater Discharge Permit (M086). Analytical results from discharge monitoring indicated that sodium, chloride and phosphorous ion concentrations in excess of Permit limits. Confirmatory sampling conducted in April 2002 by ISE generally validated the March sampling event as representative of pond wastewater. At that time, efforts were undertaken to ascertain irrigation application rates and volume applied per event. While the latter were unsuccessful for technical reasons, the independent evaluation commissioned by WRS in April did identify mechanical, operational and infrastructure limitations to operating the discharge operations in conformance with Permit conditions. All findings from the independent assessment commissioned by WRS were disclosed to MDEQ-WMD in accordance with Permit conditions and Part 22 Rules.

In furtherance of WRS's permit compliance efforts, ISE was retained to conduct an evaluation of the potential impact to groundwater resources from WRS's wastewater discharge in the first quarter of 2002 (Q1-02). This evaluation effort began in June 2002, shortly after WRS reported its findings of its non-compliant wastewater discharge. Based upon knowledge of the uppermost aquifer characteristics from a 1989 Hydrogeologic Investigation Report and prompt discovery and disclosure of the non-compliant operating condition, the assessment focused upon evaluation of vadose zone soil. With an average depth to the upper-most groundwater unit in excess of 30 feet below surface and a relatively low volume and application rate in Q1-02, assessment of vadose zone soils within the wastewater application areas provides an evaluation of conditions where impact (if any) is most likely manifested. As such, the assessment was biased toward detection of impact, if present, and allowed evaluation of potential aquifer impact, before the percolation of wastewater could reach the saturated zone.

METHODS

Soil sampling locations were based upon the random sampling plan included in the June 26th communication. Soil sampling depths were determined following evaluation of the theoretical maximum infiltration depth of applied wastewater. Utilizing WRS records of wastewater application for the first quarter of this year and local soil textural data from the Grand Traverse County Soil Survey, ISE calculated the maximum theoretical infiltration depth of applied wastewater. The algorithm used for this calculation was derived from the Environmental Protection Agency (EPA) guidance document entitled, "***Superfund Exposure Assessment Manual***" (EPA/540/1-88/001). Maximum boring and soil sampling depth selected for this assessment exceeded maximum theoretical infiltration depth to ensure that sampling and analyses encompassed the soils potentially exposed to infiltrating wastewater.

On July 8, 2002, ISE conducted soil sampling activities at the subject property. Soil borings were advanced using an AMS Model 9600 direct-push sampling apparatus. One (1) soil boring was advanced in the center of each randomly selected sector (as described in Task 2 of the work plan) for each of the former five (5) spray irrigation head locations.

Soil samples were acquired continuously from surface to a depth of approximately 20 feet below grade at each irrigation head location. Soil samples were acquired using 2-inch diameter, 4-foot macro tubes and 1½" x 4' dual tubes lined with clear acetate liners. Soil boring locations are shown on Figure 1 of Attachment 2.

Macro tubes were capped in the field, labeled for location and depth and transported to the ISE's soils and materials testing laboratory in Traverse City, Michigan for classification and further testing. While in transit, acetate liners were maintained at 4° centigrade by packing them in ice-filled coolers. At ISE's laboratory, each macro tube was reduced into 12-inch sub-sample intervals. Sub-samples were subject to textural classification in accordance with ASTM Standard Practice D-2488. Sub-samples were then transferred to sample containers supplied by SOS Laboratories of Traverse City, Michigan. Boring logs for each of the five borings are presented as Attachment 1.

Conductivity and moisture content analyses were performed on each of the 12-inch sub-samples from each boring to a depth of 12 feet. For sub-samples below 12 feet, conductivity and moisture content tests were performed at 24-inch depth intervals to a depth of 20 feet. The only exception to this method occurred for samples from SB-4A. Conductivity and moisture content tests were performed on soil samples from SB-4A at 12-inch sub-sample intervals for the entire 20-foot depth of this boring.

Soil moisture content was determined using ASTM Standard Practice D-2216. Relative soil conductivity was estimated by immersing tared, soil sub-samples into a fixed volume of distilled water of known, constant conductivity. The combined soil and distilled water were allowed to settle for a fixed time and then the liquid conductivity was measured. Soil moisture content data was used to normalize soil apparent conductivity measurements on a dry-weight basis. Based on the normalized, relative soil conductivity data, the soil moisture profiles and the theoretical maximum infiltration depth, select samples were submitted to SOS Analytical Laboratory in Traverse City, Michigan for analysis for chloride ion concentration (Task 3). Tabular presentation of moisture and apparent conductivity test results are attached as Table 1 of Attachment 2.

Following receipt of chloride ion laboratory analytical results on July 16, 2002, additional soil samples were selected for further laboratory analyses. Laboratory work included additional chloride ion analyses to further characterize vertical distribution of chloride ions and Synthetic Precipitate Leaching Procedure (SPLP) analyses to evaluate the mobility of chloride, sodium and total phosphorus ions in soil. SPLP analyses were undertaken in accordance with the June 26th Work Plan (Task 4) on soil samples that may have been impacted by infiltrating wastewater. Laboratory analytical results are summarized on Table 1. Copies of laboratory analytical reports are also included as Attachment 3.

RESULTS

The maximum theoretical infiltration depth of the wastewater applied during first quarter, 2002 was determined to be approximately nine (9) feet below ground surface, based upon the equations provided below. The precipitation data was acquired from the Traverse City's Cherry Capital Airport meteorological station. The moisture content of the vadose zone was estimated as the soil field capacity.

Infiltration Rate [in/day] = {application rate + (precipitation – evapotranspiration – runoff)} ÷ Θ
Infiltration Depth [feet] = Infiltration Rate * Elapsed Time

where: Θ = moisture content (volumetric) of the unsaturated zone

Borings were advanced to a depth twice the estimated infiltration depth to ensure that soil samples from within and below the infiltration depth were obtained and analyzed.

Soil textures from acquired soil samples were observed to be relatively uniform in the upper 20 feet from the south margins of the irrigation pond (SB-1) to the area just north of Angel Road (SB-5). Soil textures were dominantly fine-grained sand with variable (typically less than 15%) amounts of silt and coarse sand. Glacial erratics (cobbles) and gravel were observed at variable depths in several borings. Soil moisture conditions were generally observed in the field as moist with one (1) observation approaching saturated and one (1) observation of apparently dry soil. These horizons of elevated and reduced moisture content were observed below five (5) feet at SB-1 and at 15 feet below grade at SB-3, respectively.

Laboratory moisture content was somewhat variable across the site with greatest moisture contents measured in samples from SB-1A. Moisture content distribution versus depth can be observed from Table 1 of Attachment 2. Maximum moisture content was generally observed to occur between five (5) and 12 feet below surface at each boring location, nearly coincident with the estimated maximum depth of infiltration.

Relative soil conductivity measurements are all generally quite low. The maximum apparent soil conductivity observed was from sample SB-1A@ 0-1' (0.015 mS/cm-g). This coincided with the maximum chloride ion concentration detected (197 mg/kg). All other relative conductivity measurements were at least an order of magnitude less than this value with the minimum conductivity measured at nearly two (2) orders of magnitude lower than the maximum. Average and median apparent conductivity values are essentially the same value at 0.002 milliSiemens per centimeter-gram (mS/cm-g).

Total Chloride concentrations were generally very low as well, ranging from the maximum noted above down to 15 milligrams per kilogram (mg/kg). The average and median values are approximately 50 mg/kg, well below any Part 201 criteria protective of aesthetic values of drinking water or phytotoxicity concerns.

SPLP results for chloride ions were very low, most just detectable or non-detectable. Leachate analyses indicate that in general, the total chloride did not significantly leach to the aqueous phase. The maximum total chloride ion concentration yielded only six (6) mg/L chloride to the leachate. The sample yielding the greatest total chloride concentration also yielded the greatest leachate concentration. All laboratory analytical results are included as Attachment 3. These data are compiled in tabular format as Table 1 in Attachment 2.

CONCLUSIONS

Analytical results for total chloride (soils) did not indicate concentrations above the Part 201 Residential/Commercial I Generic Cleanup Criteria of 5,000 mg/kg. Analytical results of the SPLP chloride, sodium, and phosphorus did not indicate concentrations above their Part 201 Residential/Commercial I Generic Cleanup Criteria levels of 250 mg/L for chloride, 120 mg/L for sodium, and 63 mg/l for phosphorus.

Based on analytical results, it appears that the actual maximum infiltration depth of the applied wastewater is approximately 5 to 12 feet below grade and agrees well with the initial estimate at 9 feet below grade.

This evaluation included all spray irrigation areas where wastewater was applied. Soil sampling and analyses within these areas were biased toward detection of maximum concentrations present. The assessment results indicate extremely low levels of indicator chemical compounds in soil. Leachate testing indicates that a fraction of the chemicals in the solid phase (total) are transferred to the aqueous phase (SPLP leachate). It is therefore reasonable to conclude that there has been no adverse impact on soil nor will groundwater resources become adversely affected as a result of wastewater application practices beginning in the first quarter of 2002.

It is my professional opinion that no further assessment of this area is required to satisfy the Permittee's obligations under its permit or under Part 22 Rules. If you have any questions regarding this letter please contact me at (231) 933-4041.

Sincerely,
INLAND SEAS ENGINEERING, INC.

Andrew Smits, P.E.
Environmental Engineering
Department Manager

\\ise-exchange\public\ise-srv\clients\menmuir,z,k,t&quandt\02399084-williamsburg receiving and storage\reporting\consentorder\hydrogeo study july 2002 letter report.doc

ATTACHMENT 1

SOIL BORINGS LOGS

KEY TO BORING LOGS

Based on ASTM Test Method D 2488-90

SOILS ARE DESCRIBED IN THE FOLLOWING ORDER:

1) Proportional descriptions of particle sizes beginning with largest percent by volume
2) Dominant color of soil
3) Density or consistency if evaluated
4) Moisture condition of soil
5) Noteworthy observations (Visual/Olfactory)

Example: SAND, medium, some fine gravel, trace clay, brown, medium dense, moist, petroleum odor.

PARTICLE SIZE DISTRIBUTION

Gravel: Particles of rock smaller than 3.0 inch and larger than 0.20 inch in diameter, with the following subdivisions:

Coarse:	3.0 inch to 0.75 inch
Fine:	0.75 inch to 0.20 inch

Sand: Particles of rock smaller than 0.20 inch and larger than 0.003 inch in diameter, with the following subdivisions:

Coarse:	0.20 inch to 0.08 inch
Medium:	0.08 inch to 0.02 inch
Fine:	0.02 inch to 0.003 inch

Silt: Soil smaller that 0.003 inch in diameter that is nonplastic or very slightly plastic, and that exhibits little or no strength when air dry.

Organic Silt: A silt with sufficient organic content to influence the soil properties.

Clay: Soil Smaller than 0.003 inch in diameter that can be made to exhibit plasticity (putty like properties), and that exhibits considerable strength when air dry.

Organic Clay: A clay with sufficient organic content to influence the soil properties.

Peat: A soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

DENSITY & CONSISTENCY

Coarse grained soils (major portion retained on No. 200 sieve) include:

1) Clean gravels
2) Silty or clayey gravels
3) Silty, clayey or gravely sands

Consistency is rated according to standard penetration resistance.

Descriptive Term	Standard Penetration Resistance (N) Blows/Ft.
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

Fine grained soils (major portion passing No. 200 sieve) include:

1) Inorganic and organic silts and clays
2) Gravely, sandy or silty clays
3) Clayey silts

Consistency is rated according to shearing strength as indicated by penetrometer readings, vane test, or by triaxial test.

Descriptive Term	Shear strength (ksf)
Very Soft	less than 0.25
Soft	0.25-0.50
Firm	0.5-1.0
Stiff	1.0-2.0
Very Stiff	2.0-4.0
Hard	4.0 and higher

MOISTURE CONDITION OF SOIL

Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

PROPORTIONAL DESCRIPTIONS (by volume)

-y	35-50% (Gravely, Sandy, Silty, Clayey)
Some:	20-35%
Little:	10-20%
Trace:	1-10%

COMMON ABBREVIATIONS

SBS	=Split Barrel Sampler
HSA	= Hollow Stem Augers
PID	=Photoionization Detector
KS	=1"x 2' Kansas Sampler
MS	=2" x 4' Macro Sampler
PP	=Pocket Penetrometer
ST	=Shelby Tube
SA	=Screened Auger
SP	=Slotted Probe
TMW	=Temporary Monitor Well

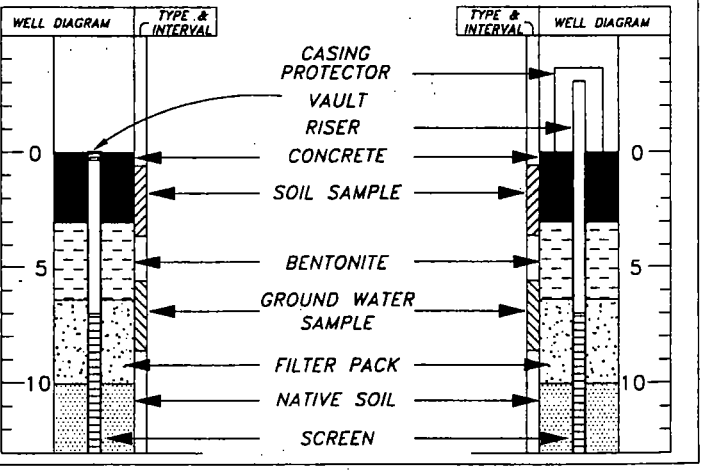
COMMON SYMBOLS

Observed Soil Horizon: ——

Inferred Soil Horizon: - - - - - -

End of Soil Boring: ——

Observed Water Table: ▽



Plot Scale: Scaled to Fit
Last Update Made On 10/14/02 At 11:03 A.M.
Current Directory: R:\DETAILS\BORINGS\KEY

INLAND SEAS ENGINEERING

Traverse City 231-933-4041
Flushing 810-487-0555

BORING: **SB-1A**

Williamsburg Receiving and Storage
Williamsburg, Michigan

PREPARED FOR:

Zimmerman, Kuhn, Darling,
Boyd, Taylor and Quandt
412 South Union Street
Traverse City, Michigan 49684

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	PID READING (ppm)	DEPTH
	GRADE Grass					
	SAND, fine, some organic material, black, wet		**MS**			
		62%				
	SAND, fine, some silt, trace gravel, brown, moist					
5	**SAND, fine, some silt, brown, wet**	**100%**				5
10	**SAND, fine, trace silt, brown, moist to wet**	**92%**				10
	SAND, fine, light brown, moist		**DT**			
15		**100%**				15
		100%				
20	**SAND. fine, brown, moist**					20
	E.O.B. 20 Feet					
25						25
30						30
35	**DT = 1 1/2" diameter, 4' dual tube sampler**					35

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Manitou Tech Services	**Scott Zenner**	**Geo Probe AMS 9600**	**7/8/2002**

Logged By:	Logging Method:	Project #:	Sheet Number:
T. Adil Chowdhury	**ASTM 2488**	**239908410**	**1 of 1**

INLAND SEAS ENGINEERING

Traverse City 231-933-4041
Flushing 810-487-0555

BORING: **SB-2A**

Williamsburg Receiving and Storage
Williamsburg, Michigan

PREPARED FOR:

Zimmerman, Kuhn, Darling, Boyd, Taylor and Quandt
412 South Union Street
Traverse City, Michigan 49684

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	PID READING (ppm)	DEPTH
	GRADE Grass					
	SAND, medium fine, some cobbles, trace silt, light brown, moist	**75%**	**MS**			
5	**SAND, fine, trace silt, light brown, moist**					5
	SAND, fine, some cobbles, little coarse, brown, moist	**100%**				
	SAND, medium fine, trace silt, light brown, moist	**100%**				
10		**100%**				10
		88%	**DT**			
15	**SAND, coarse, some cobbles, light brown, moist**	**92%**				15
		98%				
20	**SAND, fine, some cobbles, light brown, moist**					20
	E.O.B. 20 Feet					
25						25
30						30
35	**DT = 1 1/2" diameter, 4' dual tube sampler**					35

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Manitou Tech Services	**Scott Zenner**	**Geo Probe AMS 9600**	**07/08/2002**

Logged By:	Logging Method:	Project #:	Sheet Number:
T. Adil Chowdhury	**ASTM 2488**	**239908410**	**1 of 1**

INLAND SEAS ENGINEERING Traverse City 231-933-4041 Flushing 810-487-0555	BORING: **SB-3A** **Williamsburg Receiving and Storage** **Williamsburg, Michigan**	PREPARED FOR: **Zimmerman, Kuhn, Darling, Boyd, Taylor and Quandt** **412 South Union Street** **Traverse City, Michigan 49684**

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	PID READING (ppm)	DEPTH
	GRADE Grass					
	SAND, fine, trace gravel, brown, moist		**MS**			
	SAND, fine, some coarse, trace silt, brown, moist	**67%**				
	SAND, coarse, trace gravel, brown, moist					
5		**72%**				5
	SAND, fine, some coarse, dark brown, moist					
		100%				
10						10
		63%				
			DT			
15		**98%**				15
		98%				
20	**SAND, fine, some silt, little course, brown, moist**					20
	E.O.B. 20 Feet					
25						25
30						30
35	**DT = 1 1/2" diameter, 4' dual tube sampler**					35

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Manitou Tech Services	**Scott Zenner**	**Geo Probe AMS 9600**	**7/8/2002**

Logged By:	Logging Method:	Project #:	Sheet Number:
T. Adil Chowdhury	**ASTM 2488**	**239908410**	**1 of 1**

INLAND SEAS ENGINEERING

Traverse City 231-933-4041
Flushing 810-487-0555

BORING: **SB-4A**

Williamsburg Receiving and Storage
Williamsburg, Michigan

PREPARED FOR:

Zimmerman, Kuhn, Darling, Boyd, Taylor and Quandt
412 South Union Street
Traverse City, Michigan 49684

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	PID READING (ppm)	DEPTH
	GRADE *Grass*					
	SAND, fine, trace gravel, some organics, some silt, brown, dry to moist		**MS**			
	SAND, fine, trace silt, light brown, moist	**65%**				
5		**67%**				5
	SAND, fine, some silt, brown moist					
	SAND, fine, some silt, dark brown, moist	**81%**				
10	**SAND, fine, some, silt, light brown, moist**					10
	SAND, fine, trace cobbles, some silt, dark brown, moist	**92%**				
		100%				
15	**SAND, fine, trace silt, dark brown, dry to moist**					15
	SAND, fine, trace silt, light brown, moist	**100%**				
		100%				
20	**SAND, fine, trace silt, dark brown, moist**	**100%**				20
	E.O.B. 20 Feet					
25						25
30						30
35	**DT = 1 1/2" diameter, 4' dual tube sampler**					35

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Manitou Tech Services	**Scott Zenner**	**Geo Probe AMS 9600**	**7/8/2002**

Logged By:	Logging Method:	Project #:	Sheet Number:
T. Adil Chowdhury	**ASTM 2488**	**239908410**	**1 of 1**

INLAND SEAS ENGINEERING

Traverse City 231-933-4041
Flushing 810-487-0555

BORING: **SB-5A**

Williamsburg Receiving and Storage
Williamsburg, Michigan

PREPARED FOR:

Zimmerman, Kuhn, Darling,
Boyd, Taylor and Quandt
412 South Union Street
Traverse City, Michigan 49685-0987

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	PID READING (ppm)	DEPTH
	GRADE Grass					
		71%	MS			
5	**SAND, fine, trace silt, brown, moist**	78%				5
		78%				
10	**SAND, fine, some coarse, trace gravel, brown, moist**					10
	SAND, fine, some organics, trace gravel, dark brown, moist	100%	DT			
15		100%				15
		100%				
20	**SAND, fine, some silt, light brown, moist**					20
	E.O.B. 20 feet					
25						25
30						30
35	**DT = 1 1/2" diameter, 4' dual tube sampler**					35

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Manitou Tech Services	**Scott Zenner**	**Geo Probe AMS 9600**	**7/8/2002**

Logged By:	Logging Method:	Project #:	Sheet Number:
T. Adil Chowdhury	**ASTM 2488**	**239908410**	**1 of 1**

ATTACHMENT 2

FIGURES

and

TABLES

Exemption 9

TABLE 1
Soil Moisture Content and Apparent Soil Conductivity
Soil Total Chloride and Leachate Potential Analytical Results
Williamsburg Receiving & Storage
ISE Project # 02399084-10E

Boring and Depth, feet	Conductivity, mS / cm	Moisture Content, weight %	Dry Weight Conductivity, mS / cm-g	Total Chloride, mg / Kg	Synthetic Preciptate Leaching Procedure (SPLP)		
					Chloride, mg / L	Sodium, mg / L	Phosphorus, mg / L
SB1A 0-1	0.39	33.4%	1.48E-02	197	6	9.68	0.11
SB1A 1-2	0.10	18.4%	2.46E-03				
SB1A 2-3	0.10	8.3%	2.07E-03				
SB1A 3-4	0.18	7.1%	3.23E-03				
SB1A 4-5	0.30	17.1%	5.98E-03	104	3	11.20	<0.05
SB1A 5-6	0.20	20.3%	4.40E-03				
SB1A 6-7	0.26	12.4%	5.36E-03	117			
SB1A 7-8	0.16	14.5%	3.49E-03				
SB1A 8-9	0.15	14.6%	3.39E-03				
SB1A 9-10	0.16	14.6%	3.59E-03				
SB1A 10-11	0.11	18.8%	2.71E-03				
SB1A 11-12	0.15	19.4%	3.38E-03		1	8.80	<0.05
SB1A 12-14	0.05	3.0%	9.86E-04	31	1	4.27	<0.05
SB1A 14-16	0.04	2.9%	8.04E-04				
SB1A 16-18	0.05	4.0%	9.77E-04	119	1	4.96	<0.05
SB1A 18-20	0.04	2.9%	8.09E-04				
SB2A 0-1	0.08	4.0%	1.64E-03				
SB2A 1-2	0.03	2.7%	6.02E-04				
SB2A 2-3	0.07	5.4%	1.52E-03				
SB2A 3-4	0.05	2.0%	9.94E-04				
SB2A 4-5	0.07	2.4%	1.45E-03				
SB2A 5-6	0.04	2.2%	8.02E-04	22	1	5.29	<0.05
SB2A 6-7	0.11	2.9%	2.27E-03	39	1	5.63	<0.05
SB2A 7-8	0.05	3.0%	1.08E-03				
SB2A 8-9	0.10	4.6%	2.02E-03				
SB2A 9-10	0.07	4.5%	1.44E-03				
SB2A 10-11	0.07	1.9%	1.50E-03				
SB2A 11-12	0.04	2.6%	8.03E-04	30	1	4.45	<0.05
SB2A 12-14	0.05	2.3%	1.02E-03				
SB2A 14-16	0.06	3.3%	1.22E-03				
SB2A 16-18	0.07	3.1%	1.46E-03	30	1	4.13	<0.05
SB2A 18-20	0.04	3.1%	8.63E-04	15	< 1	3.63	<0.05

Boring and Depth, feet	Conductivity, mS / cm	Moisture Content, weight %	Dry Weight Conductivity, mS / cm-g	Total Chloride, mg / Kg	Synthetic Preciptate Leaching Procedure (SPLP)		
					Chloride, mg / L	Sodium, mg / L	Phosphorus, mg / L
SB3A 0-1	0.02	1.0%	3.96E-04				
SB3A 1-2	0.01	2.7%	2.01E-04				
SB3A 2-3	0.01	3.2%	1.99E-04				
SB3A 3-4	0.02	2.4%	4.40E-04				
SB3A 4-5	0.03	4.0%	6.31E-04				
SB3A 5-6	0.09	6.0%	1.90E-03				
SB3A 6-7	0.09	6.0%	1.95E-03		2	6.93	0.53
SB3A 7-8	0.05	2.5%	1.07E-03	63			
SB3A 8-9	0.08	8.4%	1.81E-03				
SB3A 9-10	0.11	7.2%	2.27E-03				
SB3A 10-11	0.16	8.8%	3.37E-03	98	2	6.05	<0.05
SB3A 11-12	0.04	8.3%	8.32E-04	30	1	5.33	0.06
SB3A 12-14	0.05	3.0%	1.01E-03				
SB3A 14-16	0.05	2.8%	1.06E-03				
SB3A 16-18	0.13	3.7%	2.66E-03	115	1	4.91	< 0.05
SB3A 18-20	0.07	2.6%	1.39E-03	77	1	3.48	<0.05
SB4A 0-1	0.29	2.4%	5.68E-03	23	1	5.94	0.11
SB4A 1-2	0.05	3.7%	1.01E-03				
SB4A 2-3	0.04	3.8%	8.25E-04				
SB4A 3-4	0.09	4.6%	1.86E-03				
SB4A 4-5	0.05	2.3%	9.42E-04				
SB4A 5-6	0.05	2.8%	1.00E-03				
SB4A 6-7	0.05	4.4%	1.02E-03				
SB4A 7-8	0.08	3.6%	1.63E-03				
SB4A 8-9	0.06	2.9%	1.18E-03				
SB4A 9-10	0.06	5.0%	1.25E-03				
SB4A 10-11	0.10	6.4%	2.03E-03				
SB4A 11-12	0.06	7.1%	1.26E-03	41	1	6.33	0.51
SB4A 12-13	0.11	3.9%	2.29E-03				
SB4A 13-14	0.05	5.0%	1.03E-03				
SB4A 14-15	0.19	2.5%	3.73E-03	32	1	5.15	<0.05
SB4A 15-16	0.12	3.4%	2.50E-03				
SB4A 16-17	0.06	4.9%	1.19E-03				
SB4A 17-18	0.03	4.3%	5.89E-04				
SB4A 18-19	0.019	4.3%	3.76E-04	25	< 1	4.95	0.40
SB4A 19-20	0.04	4.4%	8.39E-04	86	< 1	5.13	0.05

Boring and Depth, feet	Conductivity, mS / cm	Moisture Content, weight %	Dry Weight Conductivity, mS / cm-g	Total Chloride, mg / Kg	Synthetic Preciptate Leaching Procedure (SPLP)		
					Chloride, mg / L	Sodium, mg / L	Phosphorus, mg / L
SB5A 0-1	0.09	5.1%	1.63E-03				
SB5A 1-2	0.01	4.2%	2.08E-04				
SB5A 2-3	0.020	3.0%	3.84E-04				
SB5A 3-4	0.03	3.4%	5.92E-04				
SB5A 4-5	0.01	2.8%	2.27E-04	22	1	6.20	0.06
SB5A 5-6	0.07	4.4%	1.43E-03				
SB5A 6-7	0.08	3.1%	1.80E-03	72	1	5.79	<0.05
SB5A 7-8	0.06	7.5%	1.24E-03				
SB5A 8-9	0.06	4.6%	1.23E-03				
SB5A 9-10	0.05	4.1%	1.04E-03				
SB5A 10-11	0.01	3.3%	2.03E-04	76	1	6.01	<0.05
SB5A 11-12	0.10	2.8%	1.98E-03	25	1	5.62	0.11
SB5A 12-14	0.06	4.6%	1.38E-03				
SB5A 14-16	0.04	6.9%	9.71E-04				
SB5A 16-18	0.01	6.6%	2.18E-04	71	1	6.12	0.59
SB5A 18-20	0.07	7.0%	1.47E-03	65	1	5.04	0.59
Part 201 Residential/Commercial I Generic Cleanup Criteria (June 2000)				Chloride 5,000 mg / kg	Chloride 250 mg / L	Sodium 120 mg / L	Phosphorus 63 mg / L

19/isesrvr/Clients\Menmuir,Z,K,T&Quandt\02399084-Williamsburg Receiving and Storage\Data\LabData&Engineering.xls

ATTACHMENT 3

LABORATORY ANALYTICAL RESULTS

SOS ANALYTICAL

4125 Cedar Run Rd, Suite B
Traverse City, MI 49684
Phone 231-946-6767
Fax 231-946-8741
www.sosanalytical.com

RECEIVED JUL 2 0 2002

COMPANY: Z,K,D,B,T, & Q

NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022318
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/15/02
TIME RECEIVED: 2:30 PM

INORGANICS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB1A 0-1						
1 CHLORIDE EPA 9251	197	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 4-5						
2 CHLORIDE EPA 9251	104	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 6-7						
3 CHLORIDE EPA 9251	117	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 12-13						
4 CHLORIDE EPA 9251	31	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 5-6						
5 CHLORIDE EPA 9251	22	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 6-7						
6 CHLORIDE EPA 9251	39	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 11-12						
7 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 17-18						
8 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 7-8						
9 CHLORIDE EPA 9251	63	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 10-11						
10 CHLORIDE EPA 9251	98	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 11-12						
11 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	

ND = NOT DETECTED
LOD = LIMIT OF DETECTION
SMCL = FEDERAL NON-ENFORCEABLE LIMIT
MCL = MAXIMUM CONTAMINANT LEVEL
s.u. = STANDARD pH UNITS REPORTED AT 25 C
DISS = DISSOLVED

APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

SOS ANALYTICAL

4125 Cedar Run Rd, Suite B
Traverse City, MI 49684
Phone 231-946-6767
Fax 231-946-8741
www.sosanalytical.com

RECEIVED JUL 2 0 2002

COMPANY: Z,K,D,B,T, & Q
NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022318
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/15/02
TIME RECEIVED: 2:30 PM

INORGANICS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB3A 16-17						
12 CHLORIDE EPA 9251	115	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 0-1						
13 CHLORIDE EPA 9251	23	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 11-12						
14 CHLORIDE EPA 9251	41	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 14-15						
15 CHLORIDE EPA 9251	32	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 18-19						
16 CHLORIDE EPA 9251	25	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 4-5						
17 CHLORIDE EPA 9251	22	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 6-7						
18 CHLORIDE EPA 9251	72	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 10-11						
19 CHLORIDE EPA 9251	76	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 11-12						
20 CHLORIDE EPA 9251	25	10	mg/Kg (PPM)	KMC	7/16/02	

ND = NOT DETECTED
LOD = LIMIT OF DETECTION
SMCL = FEDERAL NON-ENFORCEABLE LIMIT
MCL = MAXIMUM CONTAMINANT LEVEL
s.u. = STANDARD pH UNITS REPORTED AT 25 C
DISS = DISSOLVED

APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

SOS ANALYTICAL

4125 Cedar Run Rd., Suite B
Traverse City, MI 49684
Phone 231-946-6767
Fax 231-946-8741
www.sosanalytical.com

RECEIVED JUL 2 4 2002

COMPANY: Z,K,D,B,T, & Q

NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022318
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/15/02
TIME RECEIVED: 2:30 PM

INORGANICS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB1A 0-1						
1 CHLORIDE EPA 9251	197	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 4-5						
2 CHLORIDE EPA 9251	104	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 6-7						
3 CHLORIDE EPA 9251	117	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB1A 12-13						
4 CHLORIDE EPA 9251	31	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 5-6						
5 CHLORIDE EPA 9251	22	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 6-7						
6 CHLORIDE EPA 9251	39	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 11-12						
7 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB2A 17-18						
8 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 7-8						
9 CHLORIDE EPA 9251	63	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 10-11						
10 CHLORIDE EPA 9251	98	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB3A 11-12						
11 CHLORIDE EPA 9251	30	10	mg/Kg (PPM)	KMC	7/16/02	

ND = NOT DETECTED
LOD = LIMIT OF DETECTION
SMCL = FEDERAL NON-ENFORCEABLE LIMIT
MCL = MAXIMUM CONTAMINANT LEVEL
s.u. = STANDARD pH UNITS REPORTED AT 25 C
DISS = DISSOLVED

APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

SOS ANALYTICAL

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Phone 231-946-6767
Fax 231-946-8741
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RECEIVED JUL 24 2002

COMPANY: Z,K,D,B,T, & Q

NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022318
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/15/02
TIME RECEIVED: 2:30 PM

INORGANICS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB3A 16-17						
12 CHLORIDE EPA 9251	115	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 0-1						
13 CHLORIDE EPA 9251	23	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 11-12						
14 CHLORIDE EPA 9251	41	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 14-15						
15 CHLORIDE EPA 9251	32	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB4A 18-19						
16 CHLORIDE EPA 9251	25	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 4-5						
17 CHLORIDE EPA 9251	22	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 6-7						
18 CHLORIDE EPA 9251	72	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 10-11						
19 CHLORIDE EPA 9251	76	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 11-12						
20 CHLORIDE EPA 9251	25	10	mg/Kg (PPM)	KMC	7/16/02	
SAMPLE ID: SB5A 10-11-RECHECK ORIG. EXTRACT						
21 CHLORIDE EPA 9251	49	10	mg/L (PPM)	KMC	7/23/02	
SAMPLE ID: SB-5A 11-12-RECHECK ORIG. EXTRACT						
22 CHLORIDE EPA 9251	27	10	mg/L (PPM)	KMC	7/23/02	

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LAB MANAGER

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COMPANY: Z,K,D,B,T, & Q
NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:
WILLIAMSBURG
MI
COUNTY:
TWP:

SOS PROJECT NO: 022399
SAMPLED BY: ADIL/ISE
DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/22/02
TIME RECEIVED: 12:45 PM

EPA 1312 SPLP INORGANICS/METALS

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB1A 0-1							
1	CHLORIDE EPA 325.2	6	1	mg/L (PPM)	KMC	7/30/02	
1	PHOSPHORUS-TOTAL EPA 365.4M	0.11	0.05	mg/L (PPM)	KMC	7/31/02	
1	SODIUM - EPA 273.1	9.68	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB1A 4-5							
2	CHLORIDE EPA 325.2	3	1	mg/L (PPM)	KMC	7/30/02	
2	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
2	SODIUM - EPA 273.1	11.2	1.0	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB1A 11-12							
3	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
3	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
3	SODIUM - EPA 273.1	8.80	1.0	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB1A 12-14							
4	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
4	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
4	SODIUM - EPA 273.1	4.27	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB2A 5-6							
5	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
5	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
5	SODIUM - EPA 273.1	5.29	0.1	mg/L (PPM)	VLK	7/30/02	

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DISS = DISSOLVED

APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

SOS ANALYTICAL

4125 Cedar Run Rd. Suite B
Traverse City, MI 49684
Phone 231-946-6767
Fax 231-946-8741
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RECEIVED SEP 19 2002

COMPANY: Z,K,D,B,T, & Q
NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022399
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 7/22/02
TIME RECEIVED: 12:45 PM

EPA 1312 SPLP INORGANICS/METALS

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB2A 6-7							
6	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
6	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
6	SODIUM - EPA 273.1	5.63	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB2A 11-12							
7	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
7	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
7	SODIUM - EPA 273.1	4.45	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB3A 6-7							
8	CHLORIDE EPA 325.2	2	1	mg/L (PPM)	KMC	7/30/02	
8	PHOSPHORUS-TOTAL EPA 365.4M	0.53	0.05	mg/L (PPM)	KMC	7/31/02	
8	SODIUM - EPA 273.1	6.93	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB3A 10-11							
9	CHLORIDE EPA 325.2	2	1	mg/L (PPM)	KMC	7/30/02	
9	PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
9	SODIUM - EPA 273.1	6.05	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB3A 11-12							
10	CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
10	PHOSPHORUS-TOTAL EPA 365.4M	0.06	0.05	mg/L (PPM)	KMC	7/31/02	
10	SODIUM - EPA 273.1	5.33	0.1	mg/L (PPM)	VLK	7/30/02	

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APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

SOS ANALYTICAL

4125 Cedar Run Rd, Suite B
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Fax 231-946-8741
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RECEIVED SEP 1 9 2002

COMPANY: Z,K,D,B,T, & Q

NAME:

PROJECT NO: 0239908410

WSSN:

WELL PERMIT:

TAX ID:

LOCATION:

WILLIAMSBURG
MI

COUNTY:

TWP:

SOS PROJECT NO: 022399

SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02

TIME SAMPLED:

SAMPLE MATRIX: SOIL

DATE RECEIVED: 7/22/02

TIME RECEIVED: 12:45 PM

EPA 1312 SPLP INORGANICS/METALS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB4A 0-1						
11 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
11 PHOSPHORUS-TOTAL EPA 365.4M	0.11	0.05	mg/L (PPM)	KMC	7/31/02	
11 SODIUM - EPA 273.1	5.94	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB4A 11-12						
12 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
12 PHOSPHORUS-TOTAL EPA 365.4M	0.51	0.05	mg/L (PPM)	KMC	7/31/02	
12 SODIUM - EPA 273.1	6.33	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB4A 14-15						
13 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
13 PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
13 SODIUM - EPA 273.1	5.15	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB5A 4-5						
14 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
14 PHOSPHORUS-TOTAL EPA 365.4M	0.06	0.05	mg/L (PPM)	KMC	7/31/02	
14 SODIUM - EPA 273.1	6.20	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB5A 6-7						
15 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
15 PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
15 SODIUM - EPA 273.1	5.79	0.1	mg/L (PPM)	VLK	7/30/02	

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COMPANY: Z,K,D,B,T, & Q

NAME:

PROJECT NO: 0239908410

WSSN:

WELL PERMIT:

TAX ID:

LOCATION:

WILLIAMSBURG
MI

COUNTY:

TWP:

SOS PROJECT NO: 022399

SAMPLED BY: ADIL/ISE

DATE SAMPLED: 7/8/02

TIME SAMPLED:

SAMPLE MATRIX: SOIL

DATE RECEIVED: 7/22/02

TIME RECEIVED: 12:45 PM

EPA 1312 SPLP INORGANICS/METALS

No: Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB5A 10-11						
16 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
16 PHOSPHORUS-TOTAL EPA 365.4M	ND	0.05	mg/L (PPM)	KMC	7/31/02	
16 SODIUM - EPA 273.1	6.01	0.1	mg/L (PPM)	VLK	7/30/02	
SAMPLE ID: SB5A 11-12						
17 CHLORIDE EPA 325.2	1	1	mg/L (PPM)	KMC	7/30/02	
17 PHOSPHORUS-TOTAL EPA 365.4M	0.11	0.05	mg/L (PPM)	KMC	7/31/02	
17 SODIUM - EPA 273.1	5.62	0.1	mg/L (PPM)	VLK	7/30/02	

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RECEIVED SEP 1 9 2002

COMPANY: Z,K,D,B,T, & Q

NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:

WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022657
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 8/7/02
TIME SAMPLED:

SAMPLE MATRIX: SOIL
DATE RECEIVED: 8/8/02
TIME RECEIVED: 1:00 PM

INORGANICS/METALS

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB1A 16-17							
1	CHLORIDE EPA 325.2-TOTAL	119	10	mg/Kg (PPM)	KMC	8/13/02	
1	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
1	PHOSPHORUS-EPA 365.4M/1312-SPLP	ND	0.05	mg/L (PPM)	KMC	8/15/02	
1	SODIUM - EPA 273.1/1312-SPLP	4.96	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB2A 17-18							
2	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
2	PHOSPHORUS-EPA 365.4M/1312-SPLP	ND	0.05	mg/L (PPM)	KMC	8/15/02	
2	SODIUM - EPA 273.1/1312-SPLP	4.13	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB2A 18-19							
3	CHLORIDE EPA 325.2-TOTAL	15	10	mg/Kg (PPM)	KMC	8/13/02	
3	CHLORIDE EPA 325.2/1312-SPLP	ND	1	mg/L (PPM)	KMC	8/13/02	
3	PHOSPHORUS-EPA 365.4M/1312-SPLP	ND	0.05	mg/L (PPM)	KMC	8/15/02	
3	SODIUM - EPA 273.1/1312-SPLP	3.63	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB3A 16-17							
4	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
4	PHOSPHORUS-EPA 365.4M/1312-SPLP	ND	0.05	mg/L (PPM)	KMC	8/15/02	
4	SODIUM - EPA 273.1/1312-SPLP	4.91	0.1	mg/L (PPM)	VLK	8/13/02	

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WILLIAMSBURG
MI

COUNTY:
TWP:

SOS PROJECT NO: 022657
SAMPLED BY: ADIL/ISE

DATE SAMPLED: 8/7/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 8/8/02
TIME RECEIVED: 1:00 PM

INORGANICS/METALS

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
SAMPLE ID: SB3A 18-19							
5	CHLORIDE EPA 325.2-TOTAL	77	10	mg/Kg (PPM)	KMC	8/13/02	
5	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
5	PHOSPHORUS-EPA 365.4M/1312-SPLP	ND	0.05	mg/L (PPM)	KMC	8/15/02	
5	SODIUM - EPA 273.1/1312-SPLP	3.48	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB4A 18-19							
6	CHLORIDE EPA 325.2/1312-SPLP	ND	1	mg/L (PPM)	KMC	8/13/02	
6	PHOSPHORUS-EPA 365.4M/1312-SPLP	0.40	0.05	mg/L (PPM)	KMC	8/15/02	
6	SODIUM - EPA 273.1/1312-SPLP	4.95	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB4A 19-20							
7	CHLORIDE EPA 325.2-TOTAL	86	10	mg/Kg (PPM)	KMC	8/13/02	
7	CHLORIDE EPA 325.2/1312-SPLP	ND	1	mg/L (PPM)	KMC	8/13/02	
7	PHOSPHORUS-EPA 365.4M/1312-SPLP	0.05	0.05	mg/L (PPM)	KMC	8/15/02	
7	SODIUM - EPA 273.1/1312-SPLP	5.13	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB5A 16-17							
8	CHLORIDE EPA 325.2-TOTAL	71	10	mg/Kg (PPM)	KMC	8/13/02	
8	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
8	PHOSPHORUS-EPA 365.4M/1312-SPLP	0.59	0.05	mg/L (PPM)	KMC	8/15/02	

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APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

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RECEIVED SEP 19 2002

COMPANY: Z,K,D,B,T, & Q
NAME:
PROJECT NO: 0239908410
WSSN:
WELL PERMIT:
TAX ID:
LOCATION:
WILLIAMSBURG
MI
COUNTY:
TWP:

SOS PROJECT NO: 022657
SAMPLED BY: ADIL/ISE
DATE SAMPLED: 8/7/02
TIME SAMPLED:
SAMPLE MATRIX: SOIL
DATE RECEIVED: 8/8/02
TIME RECEIVED: 1:00 PM

INORGANICS

No:	Analysis	Concentration	LOD	Units	Analyst	Date Completed	Drinking Water Reg Limit(MCL)
8	SODIUM - EPA 273.1/1312-SPLP	6.12	0.1	mg/L (PPM)	VLK	8/13/02	
SAMPLE ID: SB5A 18-19							
9	CHLORIDE EPA 325.2-TOTAL	65	10	mg/Kg (PPM)	KMC	8/13/02	
9	CHLORIDE EPA 325.2/1312-SPLP	1	1	mg/L (PPM)	KMC	8/13/02	
9	PHOSPHORUS-EPA 365.4M/1312-SPLP	0.59	0.05	mg/L (PPM)	KMC	8/15/02	
9	SODIUM - EPA 273.1/1312-SPLP	5.04	0.1	mg/L (PPM)	VLK	8/13/02	

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APPROVED BY: Shanna Shea
SHANNA SHEA
LAB MANAGER

APPENDIX F

SOIL CHARACTERIZATION REPORT
FORMER NORTHWESTERN BRINING PIT AREA
September 30, 2002

INLAND SEAS ENGINEERING

PO Box 6820, Traverse City, MI 49696
1755 Barlow Street, Traverse City, MI 49686
Phone (231) 933-4041
Fax (231) 933-4393

September 30, 2002

Mr. Joseph E. Quandt
Zimmerman, Kuhn, Darling, Boyd, Taylor and Quandt, PLC
412 South Union Street
P.O. Box 987
Traverse City, Michigan 49685-0987

RE: Soil Characterization Report
Former Northwestern Brining Pit Area
Williamsburg Receiving and Storage
ISE Reference No. 02399084-16E

Dear Mr. Quandt:

Introduction

Twenty-three (23) brining pits were formerly located on the north side of the maintenance building, on the Williamsburg Receiving and Storage (WRS) property. These brining pits were originally constructed with multiple liners composed of polyethylene (6 mils) and polyvinyl chloride (40 mils) and were used to brine sweet cherries. These pits had been emptied and for the past year the pits contained only stormwater. The stormwater was pumped out of the brining pits and the liners removed on September 13, 2002. On September 18, 2002 soil samples were collected from the former brining pits area. Construction of a stormwater retention basin in the southern portion of this area is planned to enhance control of flooding for the benefit of neighboring property owners west of the WRS plant.

The purpose of this report is to document the characterization of soils in the area of the former brining pits. Soil samples were collected and analyzed for chloride ions to evaluate:

- The potential presence of brine constituents, if any, beneath the former brine pits, and
- Determine whether a release of brine had occurred from the operation of these brining pits.

The MDEQ Waste Management Division entered into a Consent Order with WRS on August 16, 2002. Section IV(c.)(1.) of the Order requires WRS to develop a Work Plan for a Hydrogeological Investigation of the effect (if any) of waste water irrigation and brining pit operation upon groundwater resources at the site. Since vadose zone soils immediately beneath the northern brining pits have been covered by impervious surfaces since their operation initiated, then assessment of soils beneath this area provides the most immediate and complete assessment of this potential impact.

The methods used for this assessment are documented below along with the results of laboratory analyses. MDEQ guidance documents and US EPA protocols were utilized during the execution of the assessment to ensure that the work performed meets the technical requirements of MDEQ.

Methods

Sampling points were predetermined randomly using the Michigan Department of Environmental Quality (MDEQ) Verification of Soil Remediation (VSR) Guidance Document. The VSR Guidance Document was developed to evaluate contaminant concentrations at a site following cleanup activities, and to evaluate whether *facility* conditions exist following employment of a remedy. Investigations which employ the VSR practice for sample collection are biased toward identifying chemicals of concern, if present, anywhere within the remedied area. If used for assessment purposes in absence of any remedy, the VSR procedure provides a conservative evaluation approach to identify if a facility condition exists anywhere within the area subject to the practice.

Based on the VSR guidance and the area formerly occupied by brining pits, a 30-foot grid interval was selected. A total of 48 nodes were generated and are illustrated on Figure 1, Node Grid Diagram. Twelve (12) sample locations were randomly selected using the VSR. Random number generation tables were used to select nodes for sample collection. Three (3) additional side wall samples were randomly selected in the field, from the area of the future stormwater retention basin located in the southern portion of the former northern brining pit area. Please note that Node 6 was located along the east side wall of the future stormwater basin.

Eleven (11) soil samples, from the node locations (except Node 6), were collected in 250mL plastic containers from approximately one (1) foot below ground surface. Node 6 was collected from 5 foot below the existing grade. The north, south and west side wall samples were collected from depths of 2, 3, and 3 feet, respectively, below the existing grade. Samples were collected from node locations from below existing grade, and side wall locations from beneath the side wall surface, in an effort to address the historic nature of this operation and the potential for leaching and vertical mass (gravity) flow.

Sampling utensils were decontaminated between sample locations with distilled water. Samples were handled, stored and transferred in accordance with USEPA SW 846 Protocols, to Midwest Analytical Labs. Sample locations are illustrated on Figure 2, Sample Location Diagram. Chloride ions were selected for analysis as the indicator chemical of concern because Sodium, Calcium and Sulfate ions (with Chloride, these ions are the major constituents in cherry brine) react with soil. In addition to being a conservative tracer, Chloride is more abundant (mass basis) in brine than any other constituent.

Results

Laboratory analytical results were received on September 26, 2002. Analytical results indicate that chloride concentrations of the 15 samples submitted range from less than 50 mg/kg to 171 mg/kg. A summary of analytical results is presented in Table 1. A copy of the analytical results and chain of custody document are attached.

Conclusion

Laboratory analytical results indicate that the chloride concentration in each sample analyzed is below the Part 201 Residential/Commercial I, Soil Direct Contact Criteria of 500 mg/kg. As this is more restrictive a criteria than the drinking water criteria, one may conclude that soil conditions beneath the former brining pits do not meet the definition of a *facility*. Accordingly, no further assessment of this area is necessary to comply with Section IV(c.) of the Order.

If you have any questions concerning the above information, please call me at 231-933-4041.

Sincerely,

INLAND SEAS ENGINEERING, INC.

Andrew J. Smits, PE
Geological Engineer

enc.

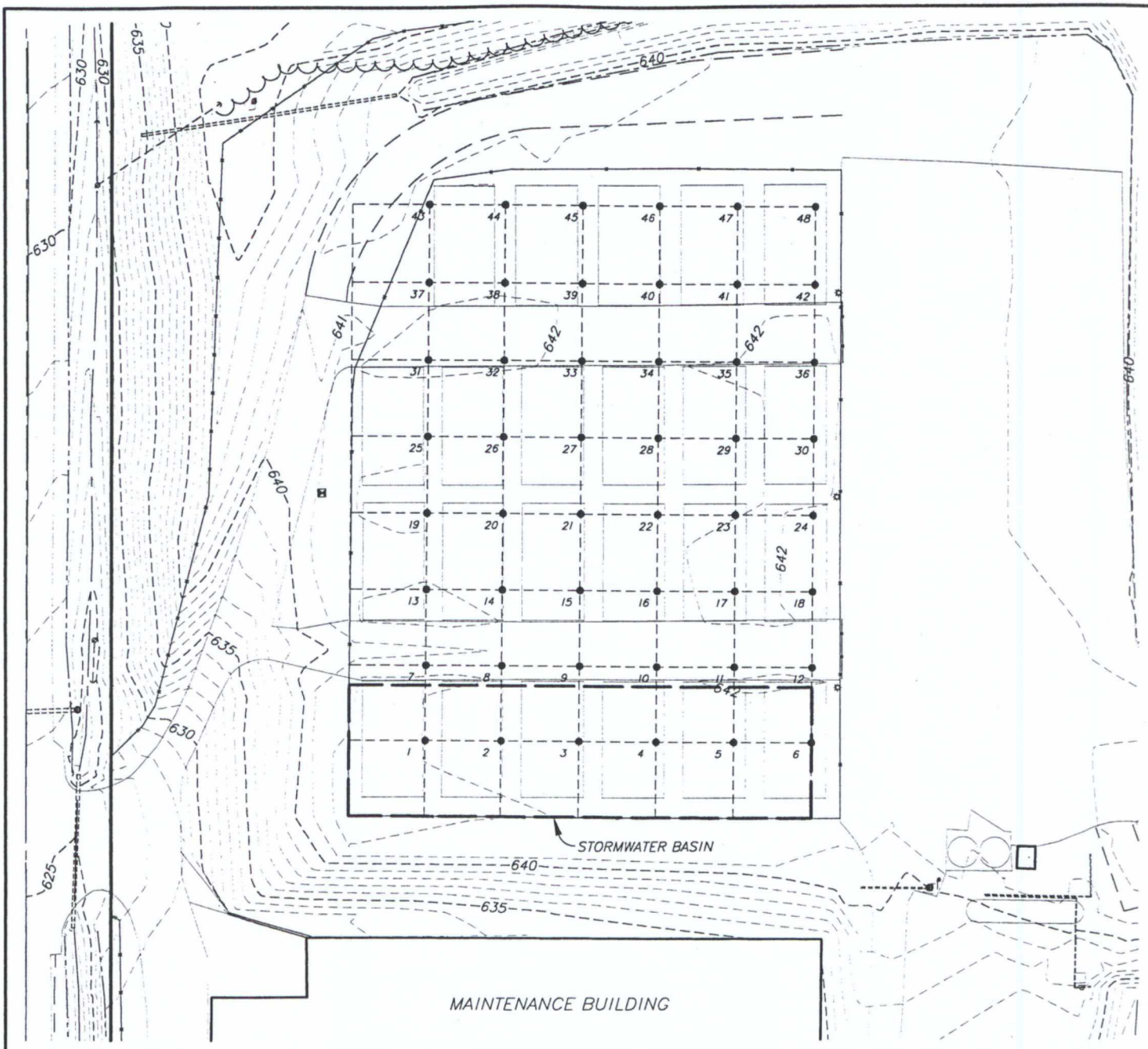
\\ise-exchange\public\ise-srv\clients\menmuir,z.k,t&quandt\02399084-williamsburg receiving and storage\reporting\soilcharacterizationreport-northwestbringingpitarea.doc

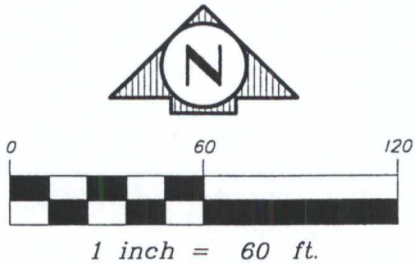
Table 1
Analytical Results
Former Brine Pit Area Soil Characterization
Williamsburg Receiving Storage

Sample Location	Chloride Concentration, (mg/kg)	Percent Solids, (%)
Node 6*	90	94.9
Node 10	107	94.1
Node 18	129	94.3
Node 26	<50	93.7
Node 27	<50	94.1
Node 31	<50	94.1
Node 33	76	93.4
Node 35	98	93.6
Node 36	<50	92.5
Node 39	105	94.2
Node 42	<50	95.7
Node 47	<50	93.2
North Side Wall	171	92.5
West Side Wall	<50	95.5
South Side Wall	52	92.3

* Node 6 = East Side Wall

Notes:
Part 201 Soil Criteria, Drinking Water Protection for chloride is 5,000 mg/kg
Part 201 Soil Direct Contact Criteria for chloride is 500 mg/kg
Date Sampled = September 18, 2002
Date Extracted = September 23 and 24, 2002
Date Analyzed = September 26, 2002
BOLD indicates concentrations which exceed Part 201 Soil Direct Contact Criteria





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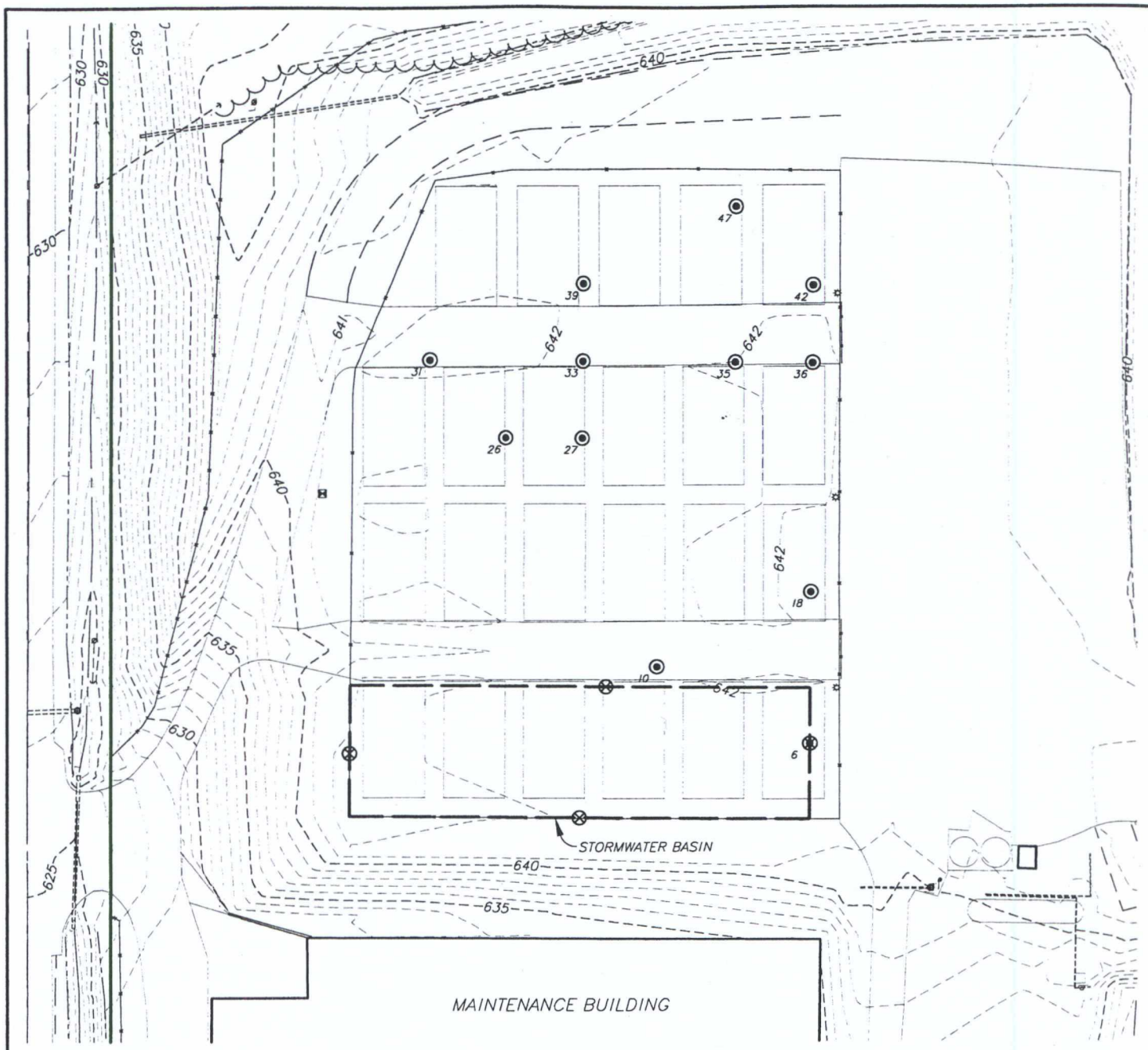
Traverse City, MI
231-933-4041
Flushing, MI
810-487-0555

NODE GRID DIAGRAM

SCALE :	1" = 60'	DRAWN BY :	T.D.R.
DATE :	9-20-02	CHECKED BY :	D.O.S.
PROJECT # :	02399084		**FIGURE 1**
DRAWING :	02399084		

Scale: 1" = 60'
Date: 09-20-2002 Time: 11:30 A.M.
CPU36 C:\Land Projects 3\dwg\02399084.dwg



N

0 60 120

1 inch = 60 ft.

LEGEND

- ⊙ SAMPLE LOCATIONS
- ⊗ SIDE WALL SAMPLE LOCATIONS

NOTE: NODE 6 IS SAME AS EAST SIDE WALL LOCATION

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Flushing, MI
810-487-0555

SAMPLE LOCATION DIAGRAM

SCALE :	1" = 60'	DRAWN BY :	T.D.R.
DATE :	9-20-02	CHECKED BY :	D.O.S.
PROJECT # :	02399084		FIGURE 2
DRAWING :	02399084		

Scale: 1" = 60'
Date: 09-20-2002 Time: 11:30 A.M.
CPU36 C:\Land Projects 3\dwg\02399084.dwg

(231) 369-3309
(231) 369-3329
(800) 253-1412
Fax: (231) 369-3331

Midwest
Analytical Laboratories, Inc.
P.O. Box 487
Kalkaska, MI 49646

RECEIVED OCT 0 1 2002

Company: Inland Seas Engineering
P.O. Box 6820
Traverse City, MI 49696

Attn: Dave Schnerer

Project #: 0239908416
Location: Williamsburg Rec. & Storage
Sample Date: 09/18/02
Sample of: Soil
Submitted Date: 09/19/02
Sampled By: ADIL
Analysis Date: 09/26/02

Analysis #	Sample Point	Percent Solids, %	Chloride Amount(mg/Kg)	Detection Limit	Extraction Date
191902	Node 6	94.9	90	50 mg/kg	09/23/02
291902	Node 10	94.1	107	50 mg/kg	09/23/02
391902	Node 18	94.3	129	50 mg/kg	09/23/02
491902	Node 26	93.7	nd	50 mg/kg	09/23/02
591902	Node 27	94.1	nd	50 mg/kg	09/23/02
691902	Node 31	94.1	nd	50 mg/kg	09/23/02
791902	Node 33	93.4	76	50 mg/kg	09/23/02
891902	Node 35	93.6	98	50 mg/kg	09/24/02
991902	Node 36	92.5	nd	50 mg/kg	09/24/02
1091902	Node 39	94.2	105	50 mg/kg	09/24/02
1191902	Node 42	95.7	nd	50 mg/kg	09/24/02
1291902	Node 47	93.2	nd	50 mg/kg	09/24/02
1391902	North Side Wall	92.5	171	50 mg/kg	09/24/02
1491902	West Side Wall	95.5	nd	50 mg/kg	09/24/02
1591902	South Side Wall	92.3	52	50 mg/kg	09/24/02

Chloride determined by USEPA Method 325.3
Extraction by ASTM Method D 3987-85 (Rotary Extraction)
nd=not detected

RECEIVED OCT 0 1 2002

Page 1 of 1

Mailing:

MIDWEST ANALYTICAL LABORATORIES, INC.
P.O. BOX 487
KALKASKA, MI 49646

SHIP TO:

MIDWEST ANALYTICAL LABORATORIES, INC.
2110 US 131 SW
SOUTH BOARDMAN, MI 49680

Company: INLAND SEAS ENGINEERING

Project Name: WILLIAMSBURG REC. & STORAGE

Project #: 02399 08416 P.O. #:

Send Results To: DAVE SCHNERER 231-933-4313 Invoice To: DAVE SCHNERER

Were Samples Rec'd Cold? Yes ☐ No ☐

Signature:

lab use	Date	Containers	No.	Sample I.D.	Type	Analysis Requested: CHLORIDE	Remarks/Preservatives
191902	09/18/02	PL	1	NODE 6	NON PRESERVED SOIL	X	
291902			1	NODE 10		X	
391902			1	NODE 18		X	
491902			1	NODE 26		X	
591902		4 OZ	1	NODE 27		X	
691902			1	NODE 31		X	
791902			1	NODE 33		X	
891902			1	NODE 35		X	
991902			1	NODE 36		X	
1091902			1	NODE 39		X	
1191902			1	NODE 42		X	
1291902			1	NODE 47		X	
1391902			1	NORTH SIDEWALL		X	
1491902			1	WEST SIDEWALL		X	
1591902			1	SOUTH SIDEWALL		X	

CHAIN OF CUSTODY RECORD

Comments:

Sampler:	Date:
ADIL	09/18/2002

Relinquished By:	Date/Time:	Recieved By:	Relinquished By:	Date/Time:	Recieved By:
ADIL	09/19/2002	0910			

Relinquished By:	Date/Time:	Recieved By:	Relinquished By:	Date/Time:	Recieved By:	Date/Time:

APPENDIX G

AMERICAN SOCIETY FOR TESTING AND MATERIALS

REFERENCE STANDARDS UTILIZED
IN THE
EXECUTION
OF THE
PROPOSED HYRDOGEOLOGIC STUDY

ASTM STANDARDS RELATED TO ENVIRONMENTAL SITE CHARACTERIZATION

Sponsored by Committee D-18 on Soil and Rock

1997

ASTM Publication Code Number (PCN): 03-418297-38

ASTM
100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

COMPILATION OF STANDARDS ON ENVIRONMENTAL SITE CHARACTERIZATION

Topical Table of Contents

PART 1. SITE CHARACTERIZATION

1.1 General Guidance

1.2 Data Elements

1.3 Geophysical Methods

1.4 Geologic Characterization

2.3 Sediment Sampling

PART 3. WATER SAMPLING AND MONITORING

3.1 General

3.2 Water Sampling

3.3 Ground Water Monitoring Wells (see also drilling methods, Section 1.6)

3.4 Ground Water Sampling

PART 4. WASTE/CONTAMINANT CHARACTERIZATION AND SAMPLING

4.1 General Guidance

APPENDIX H

BORING LOG FORMS
MONITORING WELL CONSTRUCTION RECORDS
AND
TYPICAL MONITORING WELL DETAILS

KEY TO BORING LOGS

Based on ASTM Test Method D 2488-90

SOILS ARE DESCRIBED IN THE FOLLOWING ORDER:

1) Proportional descriptions of particle sizes beginning with largest percent by volume
2) Dominant color of soil
3) Density or consistency if evaluated
4) Moisture condition of soil
5) Noteworthy observations (Visual/Olfactory)

Example: SAND, medium, some fine gravel, trace clay, brown, medium dense, moist, petroleum odor.

PARTICLE SIZE DISTRIBUTION

Gravel: Particles of rock smaller than 3.0 inch and larger than 0.20 inch in diameter, with the following subdivisions:

Coarse:	3.0 inch to 0.75 inch
Fine:	0.75 inch to 0.20 inch

Sand: Particles of rock smaller than 0.20 inch and larger than 0.003 inch in diameter, with the following subdivisions:

Coarse:	0.20 inch to 0.08 inch
Medium:	0.08 inch to 0.02 inch
Fine:	0.02 inch to 0.003 inch

Silt: Soil smaller that 0.003 inch in diameter that is nonplastic or very slightly plastic, and that exhibits little or no strength when air dry.

Organic Silt: A silt with sufficient organic content to influence the soil properties.

Clay: Soil Smaller than 0.003 inch in diameter that can be made to exhibit plasticity (putty like properties), and that exhibits considerable strength when air dry.

Organic Clay: A clay with sufficient organic content to influence the soil properties.

Peat: A soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

DENSITY & CONSISTENCY

Coarse grained soils (major portion retained on No. 200 sieve) include:

1) Clean gravels
2) Silty or clayey gravels
3) Silty, clayey or gravely sands

Consistency is rated according to standard penetration resistance.

Descriptive Term	Standard Penetration Resistance (N) Blows/Ft.
Very Loose	0-4
Loose	5-10
Medium Dense	11-30
Dense	31-50
Very Dense	Over 50

Fine grained soils (major portion passing No. 200 sieve) include:

1) Inorganic and organic silts and clays
2) Gravely, sandy or silty clays
3) Clayey silts

Consistency is rated according to shearing strength as indicated by penetrometer readings, vane test, or by triaxial test.

Descriptive Term	Shear strength (ksf)
Very Soft	less than 0.25
Soft	0.25-0.50
Firm	0.5-1.0
Stiff	1.0-2.0
Very Stiff	2.0-4.0
Hard	4.0 and higher

MOISTURE CONDITION OF SOIL

Dry:	Absence of moisture, dusty, dry to the touch
Moist:	Damp but no visible water
Wet:	Visible free water, usually soil is below water table

PROPORTIONAL DESCRIPTIONS (by volume)

"y	35-50% (Gravely, Sandy, Silty, Clayey)
Some:	20-35%
Little:	10-20%
Trace:	1-10%

COMMON ABBREVIATIONS

SBS	=Split Barrel Sampler
HSA	= Hollow Stem Augers
PID	=Photoionization Detector
KS	=1"x 2' Kansas Sampler
MS	=2" x 4' Macro Sampler
PP	=Pocket Penetrometer
ST	=Shelby Tube
SA	=Screened Auger
SP	=Slotted Probe
TMW	=Temporary Monitor Well

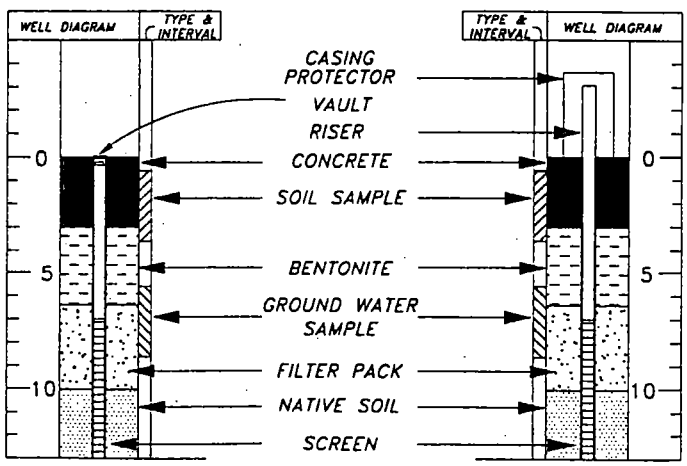
COMMON SYMBOLS

Observed Soil Horizon: ——

Inferred Soil Horizon: ·····

End of Soil Boring: ——

Observed Water Table: ▽



Plot Scale: Scaled to Fit
Last Update Made On 10/14/02 At 11:03 A.M.
Current Directory: BC:\DETAILS\BORINGS\KEY

INLAND SEAS ENGINEERING

Traverse City 231.933.4041
Flushing 810.487.0555

BORING/WELL:

PREPARED FOR:

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	HAND PENETROMETER (TSF)	TYPE & INTERVAL	BLOW COUNT	DEPTH
	GRADE						

Drilling Contractor:	Driller:	Drilling Method:	Date Drilled:
Logged By:	Logging Method:	Project #:	Sheet Number:

INLAND SEAS ENGINEERING

Traverse City 231.933.4041
Suttons Bay 231.271.4535
Flushing 810.487.0555

WELL: MW-27

[redacted]
206 N. MAIN STREET
LAKE CITY , MICHIGAN 49651

PREPARED FOR:

[redacted] OIL COMPANY
[redacted]
[redacted] MICHIGAN 49686

DEPTH	SOIL DESCRIPTION AND COMMENTS	PERCENT RECOVERY	SAMPLE METHOD	TYPE & INTERVAL	WELL DIAGRAM	DEPTH
	GRADE GRASS AND TOPSOIL					
	PEAT, BLACK, MOIST					
5						5
10						10
	SAND, FINE, YELLOW- BROWN, MOIST					
15						15
20						20
25						25
	SAND, FINE, YELLOW-BROWN, WET					
30						30
	E.O.B. @ 33'					
35						35

Example

Drilling Contractor: SHEPLER	Driller: RANDY SHEPLER		Drilling Method: H.S.A	Date Drilled: 12/11/00
Logged By: RWE	Logging Method: ASTM 2488	Development Method: BAILER		Project #: 98072052
Casing Type: 2" PVC	Screen Type & Length: 2" PVC-10 SLOT-36"	Ground Elevation: NA	Top of Casing Elevation: NA	Sheet Number: 1 OF 1

INLAND SEAS ENGINEERING, INC.

STATIC WATER LEVEL AND SAMPLING DATA SHEET

LOCATION _____

DATE _____

CLIENT _____

INIT. _____

WELL I.D.	SAMPLE ORDER	TOTAL DEPTH	DEPTH to WATER	FEET of H_2O	# of BAILS	OBSERVATIONS

Note: For 3 Well Volumes, Ft. of H_2O X 3 = # Bails in 2" Well ; Ft. of H_2O X 2 = # Gallons in 4" Well ; 3.6 Bailers = 1 Gallon

APPENDIX I

PROPOSED SCHEDULE FOR IMPLEMENTATION